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TRANSACTIONS

OF

THE FEDERATED INSTITUTION

OF

MINING ENGINEERS.

VOL. X.—1895-96.

EDITED BY M. WALTON BROWN, SECRETARY.

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TRANSACTIONS

OF

THE FEDERATED INSTITUTION

OF

MINING ENGINEERS.

THE FEDERATED INSTITUTION OF MINING ENGINEERS.

STUDENTS' MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,

AUGUST 13TH, 1895.

MR. R. O. BROWN IN THE CHAIR.

Mr. M. WALTON BROWN, in explaining what had led to the present Students' Meeting, said the Council saw that the students were not attending the General Meetings which were held in the various districts, and they thought it was possible that the students did not care to express their views before the older members. Consequently, the Council of The Federated Institution of Mining Engineers suggested that such meetings should be held. Mr. T. A. Southern and himself prepared a draft scheme which was submitted to and adopted by the Council, and a prize was offered for the best paper on the subject of "The Prevention of Accidents in Mines."

Mr. AUSTIN KIRKUP read the following paper on "The Prevention of Accidents in Mines":—

THE PREVENTION OF ACCIDENTS IN MINES.

By AUSTIN KIRKUP.

The subject of this essay is most important to all of us who are engaged about mines. In our daily work underground as colliery officials, the most important duty which we have to perform is to see that all the different operations of mining are carried out in as safe a manner as possible. We have to carry out the Coal Mines Regulation Act, together with the General Rules, which have been framed for the purpose of preventing as far as possible the occurrence of accidents in mines. In addition to the General Rules there are the Special Rules of each mining district applicable to each colliery, and these are "for the conduct and guidance of the persons acting in the management of, or employed in or about the mine."

There is no doubt that the legislative enactments in connexion with mines have had a most beneficial effect on the safe working of collieries. This is the more obvious when we compare the deaths from accidents in mines at the present time with what they were 25 years ago. On reference to statistics which have already appeared in the *Transactions* of The Federated Institution of Mining Engineers the writer finds that in the year 1868 the lives lost were at the rate of 1 in every 343 persons employed, and in 1893 (the latest statistics available) the ratio was 1 in every 676 persons employed.* These statistics speak for themselves. They show the increased conditions of safety under which the miner now works. This improvement is due partly to the mining legislation enacted since 1868, and partly to the improved safety-appliances which have been introduced during recent years, chiefly by means of the educating influences of the mining institutes. It is only necessary to instance the high perfection of present-day mechanical ventilators and safety-lamps to prove the truth of this latter assertion.

But in spite of this improvement, the death-rate from accidents is still comparatively high. Fortunately we are not so often, as in former years, appalled by some disaster involving enormous loss of life, although

* "Presidential Address," by Mr. John Nevin, vol. viii., page 288.

the writer is sorry to say that this class of accident has not altogether disappeared. But it is not these great accidents which swell our death-roll to such an extent. On analysing the accident list we find that (what the writer may call) the individual accidents, when collected, form an alarming total.

The writer proposes in this essay to deal with each of the different classes of accidents, with especial reference to those accidents which we all, at more or less frequent intervals, witness in our individual capacities at collieries.

According to the reports of H.M. Inspectors of Mines for 1893, the number of deaths from accidents in that year was 1,060, and they have been divided into seven classes, which may be enumerated as follows :—

	No. of Deaths.		Per Cent.
1. Explosions	160	or	15·10
2. Falls	412	„	38·89
3. Shafts	103	„	9·70
4. Explosives and Suffocation ...	29	„	2·73
5. Tubs or Engine-planes	131	„	12·36
6. Sundry causes (underground) ...	105	„	9·90
7. Surface *	120	„	11·32

As previously stated, the most complete method of dealing with the subject which suggests itself to the writer is to deal with each class of accident in succession, but with reference more particularly to accidents from falls, tubs, or engine-planes, and such other accidents as have come within his own observation.

Explosions.—Perhaps in no branch of science has the benefit of research and the subsequent legislation attendant on important discoveries for the prevention of accidents been more conspicuous than in that part of science dealing with the cause of explosions and the precautions to be used for preventing them. The frequency of these terrible disasters caused special attention to be devoted to them by mining engineers and scientific experts, with the result that to a large extent the deplorable state of things which once existed has been remedied.

As every one knows, there is one gaseous substance found in mines which, when brought into contact with flame after being mixed with a sufficient volume of air, will explode. This gas is known as fire-damp. There is also another substance—in this case a solid—which will in every case extend the effects of a gas-explosion far beyond the limits of the gas

* "Presidential Address," by Mr. Thos. Douglas, *Trans. Fed. Inst.*, vol. viii., page 240.

itself, and which, under favourable circumstances, is capable of initiating an explosion in the entire absence of fire-damp. This substance is coal-dust. As far as now known, gas and coal-dust are the only agents capable of producing explosions in mines, and to dilute the one with air and to destroy the other is the only method of rendering them harmless.

The most explosive mixture of gas and air is in the proportion of 1 of gas to 9·4 of air, and the least explosive is 1 of gas to 15 of air. When more air is added, the mixture becomes unexplosive, and therefore harmless so far as the presence of lights is concerned. Hence the first requirement of every fiery mine is a sufficient ventilation "to dilute and render harmless noxious gases to such an extent that the working-places of the shafts, levels, stables, and workings of the mine shall be in a fit state for working and passing therein."

The ventilation of all mines of any extent is produced by artificial means—the furnace or the fan—the principle of which it is not here necessary to explain. But there is one fact in connexion with the circulation of large volumes of air which the writer wishes to lay special stress upon, namely, the necessity of good airways. Many mines are at a disadvantage in this respect. In some cases the shafts are too small, but oftener it is the underground roads, more especially the return-airways. These roads are not usually intended for haulage or travelling, and are allowed to get into a bad state. The sectional area in many parts is very small. Acute bends are frequent and, where faults are met with, the air in many cases is deflected from a horizontal to a vertical course. These irregularities add greatly to the friction of the air-current, and to the power required to produce a given quantity of air.

In order to ensure good results, the sectional area of the return-airways should be equal to that of the intake-airways, sharp bends should be avoided as much as possible, the abruptness of faults should be smoothed down, and the air should have as easy and straight a road as may be to the upcast shaft.

The writer has had the good fortune to be connected with a colliery where these conditions have been observed. The workings are most extensive, stretching away over 3 miles from the shafts; the ventilation is by furnaces and boiler-fires; there are two downcast pits 14 feet in diameter, and one upcast pit of the same area: the quantity of air, as measured in the main intake-airways, is 480,000 cubic feet per minute: the velocity in the upcast pit is more than 3,000 feet per minute: this ventilation is maintained by a furnace; and the water-gauge, even in winter, never rises above 2·50 inches.

So much for the necessity of a good ventilation and the means of producing the same. If space had permitted, the writer might have gone into the question of the absolute economy of forming good airways in a mine and shown the enormous saving of coal and engine-power under such conditions, but he knows that to do so would be to wander away from the subject of this essay.

There are other precautions against explosions to which it is necessary to refer. The accumulation of gas in old workings should be guarded against by a system of thorough inspection; where gas is being evolved in old workings which cannot be ventilated it should not be stopped off; the workings should be placed in connexion with the return-airways, so that the gas as it is generated may expand into them and be diluted by the current.

The general and special rules of the Coal Mines Regulation Act in relation to gas must be stringently enforced, as absolute discipline and obedience to orders are the chief factors in the safe working of a colliery. It is not necessary here to repeat the rules which by law must be observed. They are fully stated in the abstract of the Act and the special rules of every mine. But, with reference to safety-lamps, the writer thinks that in addition to being examined they should be tested in coal-gas and air before being locked and sent into the mine. This test proves their safety and prevents any part of the lamp from being omitted when it is being fitted together after examination.

It will not be amiss at this point, when dealing with safety-lamps, to digress for a moment and say a few words about fire-damp detectors. It is hardly necessary to explain that these instruments are used to detect minute proportions of gas such as are not visible on the ordinary oil-flame of a safety-lamp. They are therefore useful for ascertaining the proportion of gas present in the main return-airways of a fiery mine, more especially when the ventilation is produced by a furnace fed—as in the majority of cases—by the return air-current. An ordinary safety-lamp will only detect gas when the proportion of gas in the current is 2 per cent. or more, and when it is remembered that it is unsafe to fire shots in a dusty mine in air containing 2 per cent. of gas, it will be seen that the systematic use of a fire-damp detector in a fiery mine may in many instances reveal hidden dangers.

The writer has had considerable experience with fire-damp detectors, at first with the Pieler lamp and more recently with the Clowes hydrogen gas-detector. Both these instruments have been described to and discussed by the members of this Institution, and are probably better

known than any other form of fire-damp detector. The results which the writer has obtained have been both interesting and instructive. Periodical tests should be made in the main return-airways with the gas-detector, and any increase in the percentage of gas due to increased working or decreased air-current or atmospheric depression is immediately shown. It seems probable that, as fire-damp detectors become better known, they will no longer be regarded as scientific toys, seeing that they give such reliable indications of the state of the return air-currents.

The writer has already alluded to that property of coal-dust, whereby an explosion may be extended far beyond the limits of the gas. It is also an undoubted fact that under certain conditions coal-dust mixed with air alone will produce an explosion. These conditions are seldom attained except during the process of shot-firing, although instances are on record of dust taking fire on the screens at the surface. Nevertheless it is a recognized fact that during shot-firing we have most to fear from coal-dust. The fiery blast from a shot-hole in the presence of coal-dust is increased by the combustion of the dust-particles, and where sufficient dust is present to feed the flame a blast of explosive violence is formed which often extends for long distances. When small proportions of gas are present in such dust-laden air, the initiation and extension of an explosion is facilitated. The danger arising from firing shots in the presence of coal-dust has been recognized by Parliament, and provisions for thorough watering in the vicinity of a shot are embodied in the Coal Mines Regulation Act of 1887. At the present moment, a Bill to provide for more extensive systems of watering on all dry roads underground, and other precautions during blasting, is being drafted for the approval of Parliament. From this it will be seen that, so far as watering is concerned, all reasonable precautions are being taken to prevent accidents from explosions of coal-dust during shot-firing.

There are one or two other points in relation to shot-firing which the writer will mention in concluding this part of his subject. He thinks that too much care cannot be exercised in choosing the officials who are to superintend the firing of shots. The commonest cause, he may almost say the only cause of a dust explosion, is the occurrence of a blown-out shot. This is generally due to the injudicious choice of a shot-hole, combined with the use of too great a weight of explosive and too short a length of stemming. Blown-out shots should be, as far as possible, prevented, and the sole way of doing so, that occurs to the writer, is to employ only such officials at this work as are thoroughly qualified by experience and intelligence to calculate the correct position of a shot-hole

and the weight of explosive necessary to do the desired amount of work. The writer ventures to think that this is not always done.

The last point in relation to shot-firing is the use of blasting-powder in dusty mines. In many mines its use has been abolished; in many more it should be abolished. It produces a heavy shower of sparks and flame, which are most favourable for the initiation of an explosion. Only such explosives should be used as will give a minimum of flame, and devices for the extinction of flame in shot-holes should be more resorted to.

There are many more proposals for the prevention of accidents in mines from explosions which the writer might have dealt with, such as the compulsory use of safety-lamps in all mines, the abolition of all underground fires, boiler-fires, furnace or otherwise, and the abolition of blasting in all mines. For the most part they will not bear criticism, for it goes without saying that before abolishing an useful agent we should find something equally good to put in its place.

Falls.—In dealing with the subject of falls, the writer knows that it is one with which we are all acquainted. It is a very frequent occurrence at every colliery to have accidents, of a more or less serious nature, from falls, which in many cases involve loss of life. This fact is the more apparent on referring to the statistics of deaths from various causes, which have already been given. We find that 38·89 per cent. of the total deaths from accidents in the United Kingdom are due to falls. It is also worthy of note by those employed in the northern coal-field that 56 per cent. of the deaths from accidents* in this district during 1892 were caused by falls.

With these facts before us, the subject assumes an enhanced importance, and it is well worth while considering the causes and possible prevention of this excessive death-rate.

These accidents may be classed under three heads :—

1.—Falls of coal.

2.—Falls of roof-stone in face.

3.—Falls when withdrawing timber.

1. *Falls of Coal.*—Falls of coal occur when the seam is undercut or kirved, and the overhanging portion of coal is not sufficiently spragged. The Coal Mines Regulation Act, in dealing with the rule for spragging, says :—"The distance between the sprags or holing-props, where they are required, shall not exceed 6 feet or such less distance as may be ordered by

* "Presidential Address," by Mr. A. L. Steavenson, *Trans. Fed. Inst.*, vol. vi., page 280.

the owner, agent, or manager." The writer thinks that in this rule the words "where they are required" should be omitted. He considers that wherever coal is kirved to a considerable distance, say 2 feet and above, and where the miner has to work in a prone position, often partially under the overhanging coal, sprags should be compulsorily used, a certain maximum distance apart being fixed.

During the time he has been connected with collieries, the writer has had continual experience of straight-face longwall working where the coal was undercut to a depth of not less than 3 feet. The coal-seam to which he refers is hard, and the cleats of the coal are in many places as far as 18 inches apart. This coal when struck with the pick sounds hard and safe, but as soon as the hewer has undercut through to the cleats it not infrequently happens that the coal breaks off and would fall on to the workman beneath if it were not sufficiently stayed or spragged.

In many seams backs or slips occur. These are somewhat different from cleats. They are fractures in the coal-seams, occurring every few feet, and have a dull black appearance. They do not lie at right-angles to the floor, but are sometimes inclined towards, and sometimes from, the workman. When inclined towards the workman, spragging must be very carefully and systematically done, because when undercut to the next slip the coal is apt to fall forward suddenly on to the workman beneath.

The same coal-seam differs very much even at adjoining collieries, and the writer favours the idea of each manager formulating a set of rules for the colliery under his charge, in which he shall state the maximum distance apart at which sprags shall be set, and that in no case shall coal remain unspragged.

Even with the greatest precautions and the strictest discipline accidents frequently happen, due solely to the carelessness of the workmen. A case of this kind occurred under the writer's observation a year or two ago in a coal-seam which was divided by a dirt-parting 18 inches from the top of the seam. The men were not allowed to work the two sections of the seam separately, because accidents had previously happened owing to the workmen neglecting to timber the top coal. In the case referred to, the workman had, despite the protestations of his fellow who was working with him, first worked out the bottom section of the seam, with the result that the top coal fell away and killed him. This accident should never have occurred, and the workman came to his death by his own imprudence. For such cases as this we cannot legislate.

2. *Falls of Stone.*—Falls of stone in the face occur when the support afforded by the coal is removed and a sufficiency of timber is not set.

The roof or cover of all coal-seams differs much, and all roofs require more or less timbering. In some seams the roof requires support as soon as the coal has been extracted for a very short distance; in others the stone is coherent, and will allow the miner to proceed for several feet before setting any timber. It is a notorious fact that practically all the accidents from falls of roof occur under good stone, which points to the fact that stone, however good, is not to be trusted. Even under a firm shale or blue metal roof we occasionally meet with slippery partings and cauldron bottoms, and these are probably the worst enemies which the miner has. Without a word of warning they drop out, and generally they are of such a size as to kill or permanently injure the unfortunate workman beneath. Under a sandstone roof, which is generally the safest of all roofs, we not infrequently have coal-pipes or partings only dangerous in a lesser degree than the cauldron bottom.

We are commanded by general rule 21 of the Coal Mines Regulation Act to make the roof and sides of every travelling-road and working-place secure, and to the best of our knowledge this is done; but unfortunately our knowledge is sometimes at fault, and consequently we have accidents occurring in places which we thought to be absolutely safe. What remedy can we apply to this state of things? This question has been often asked, but not many answers have been vouchsafed to it. We are told that the ordinary safety-lamp does not give sufficient light to allow of the miner discovering the joints which traverse the roof of all coal-seams. The writer thinks that to a great extent this is true, and that too much attention has been given to providing a lamp which will be safe in explosive currents, which are seldom, if ever, met with in mines, and that too little attention has been given to the improvement of the luminous power of the lamp, which is a very important matter.

We certainly need more light in mines, but with the present system of oil safety-lamps any improvement appears to be impossible. A larger flame inside a safety-lamp would unduly heat the gauze or maybe crack the glass. Besides, the ordinary flame inside a safety-lamp is often partially hidden by the gauze completely surrounding the flame, this being an additional precaution against gas and, even in lamps of the Marsaut type, the air to feed the flame has to pass through two and sometimes three gauzes, which during the course of a shift often become clogged with dust-particles. There only remains for us the electric light: burning as it does in a vacuum, it is not affected by the outside conditions, and a greatly improved light is given. The great objection to its use, seems to be that it does not indicate the state of the air which

the miner is breathing. This is certainly a drawback, but one which doubtless may be remedied in the future. If the electric light could be combined in a portable form with a gas-detector the acme of success in the lighting of mines would have been attained. It is for those who are interested in the safe working of collieries to solve this problem.

Referring again to the fact that accidents occur most frequently under good stone, it has been proposed as a remedy that all working-places be timbered, a maximum distance being fixed at which the timber shall be set. This rule would no doubt entail considerable extra cost both in material and labour, but it is obviously the nearest approach to a solution of the difficulty which has been proposed. Many owners oppose it, because of the extra cost incurred, and in these days of coal-trade depression costs must be carefully watched. Nevertheless these accidents occur, and we should do our best to prevent them.

While busy with the subject of this essay, the writer was startled by an accident which has a bearing on this part of the subject, and which partly explains why he has ventured to touch on the question of compulsory timbering. The accident referred to occurred in a district of a coal-seam where the stone was considered to be exceptionally good. The cover was blue metal, or shale of a very tenacious kind, and great difficulty was experienced in wedging down the stone to make height in the main roads. The accident happened to a coal-hewer; while he was working at the face a stone weighing 4 tons fell out and killed him. The stone was 2 feet thick and over 6 feet in diameter, being of a perfect saucer-shape, and extremely slippery on its upper surfaces. As may be imagined, it sounded quite hard and safe and gave no warning of its fall. How are we to prevent accidents of this kind? In the absence of any other suggestion, the writer thinks that recourse must be had to a system of compulsory timbering at the working-faces. Where the stone is exceptionally good, the timber will nearly all be recovered and may be used over and over again, so that the increased cost would not be so great as may be at first imagined.

The writer offers this opinion on the subject of compulsory timbering, fully expecting that it will be adversely criticized by many practical engineers, but he would remind them that the subject of this essay is the prevention of accidents, and he has indicated what appears to be the nearest approach to a remedy for the many accidents caused by falls of stone.

Before leaving this part of the subject, reference must be made to the prevalence of accidents from falls of side or side-wavers. To those unaccustomed to the technical terms of the North of England coal-field,

the writer may say that side-wavers are due to stone projecting over the top of the coal-seam in waggonways and other main roads, after the top canch or ripping has been taken down. It often happens that in such roads the top stone is only taken down in the middle of the road, of a sufficient width to allow of the passage of the horses and tubs. The stone at either side is left more or less unsupported, and in course of time, through being exposed to the air, is fractured along a line immediately over the coal-seam into which the air cannot penetrate to any depth. When the pillars of coal are being worked, and the coal at this particular point is in course of removal, this fractured stone or side-waver falls, very often with fatal results. To prevent such occurrences the top canch or ripping should be taken down, in the first instance, to the coal-wall side. Side canches should be scrupulously avoided, as they are extremely dangerous, in fact where height must be made, and both top and bottom are equally favourable, it is better to take up bottom stone, and thus avoid any danger whatever from the side top canch.

3. *Falls when Withdrawing Timber.*—Accidents from this cause are deplorably common, and the writer cannot foresee that much improvement will be made in the direction of safety. It goes without saying, that the most experienced workmen should be employed at this work, and when this is done, it is easy for us to recall accidents to the most careful workman while withdrawing timber. At one accident, which occurred under the writer's notice, it was suggested by H.M. Inspector of Mines that the workmen should have set some timber to protect themselves as they came out-bye. This is a good suggestion, as it decreases the liability of a stone falling suddenly. To some extent, it is an argument in favour of compulsory timbering, because in such a case the timber would be already set, and when being withdrawn there would not be the same chance of the stone breaking over the thickly-set timber under protection of which the miners are working. Under any conditions the work is extremely dangerous, and too much care cannot be exercised in carrying it out.

Shaft Accidents.—The shafts of a colliery are the sole outlets for all the mineral produced and are also the only means by which we may enter or leave the mine. They are converted by means of conductors or guides into what may be called a vertical railway in which cages run; and considering the enormous distance traversed by such cages in each day, the speed of winding, and the frequency with which the motion of the cages has to be reversed, the writer feels that he may safely say that accidents

do not frequently happen. This much at least we may assert, that in no branch of mining engineering has the improvement of recent years been more rapid than in the condition of the winding tackle. And this improvement has been reflected in the diminution of accidents in shafts. Nevertheless, we still have occasional mishaps—as is seen by the fact that during the year 1893 there were 103 accidents of this class in the United Kingdom, or 9·70 per cent. of the total number of accidents in mines. The writer proposes to briefly review the chief causes of these accidents and to make what remarks occur to him on their prevention.

The first cause of shaft accidents which occurs to the writer is the breaking of the winding-rope. This does not happen so frequently as in former years, in fact it is a class of accident which happily seldom occurs nowadays. The introduction of steel wire-ropes is mainly responsible for this improved state of things. The first essential of a good rope is that it should be of uniform quality and strength, and this is the leading feature of the steel wire-rope. A very high state of perfection has been reached in their manufacture, and ropes can now be obtained which for quality and workmanship leave nothing to be desired. When ropes do break it is generally found that corrosion has occurred inside the rope and has weakened the inside wires, without being visible by external examination. A case occurs to the writer's mind of an accident which happened under exactly these conditions. The rope in question was made by a well-known firm. An external examination revealed no broken wires or other defects, but it was found that at the point of fracture the wires of the rope were internally corroded and capable of bearing only a moderate strain. Probably the only precautions to be used in such a case would be not to allow the winding-rope to be used for too prolonged a period, and they should be frequently changed. In many instances the old winding-rope might be used in drop-staples where men do not generally ride, or possibly in these days of auxiliary haulage for hauling up a short dip drift. In any case they should be changed at stated periods independently of the work which they have done, because it is a fact that the weather often does more damage to the rope than the actual strain of winding coals. Therefore, when in use, the rope should be as far as possible protected from the weather.

Another point in connexion with the proper usage of ropes is that, when not in use, the cages should not be always allowed to hang at precisely the same place in the shaft, because in such a case one particular portion of the rope is always lying on the pulley, being thus continually exposed to the weather, and unduly strained owing to its curvature over

the pulley. The writer has often noticed that generally each engineman, when taking the cage bye, works his engine a certain number of revolutions, which number he never varies, with the result that in many cases the same portion of the rope is being exposed to the weather, a state of things which must deteriorate the rope more rapidly at that point. The engineer of the colliery should periodically vary the position at which the cage shall hang in the shaft, so as to avoid unfair treatment to any one portion of the rope. Another commendable practice, which many mining engineers follow, is to frequently re-cap the rope, and by so doing the portion of the rope where the greatest strain takes place is removed, and the internal condition of the rope ascertained.

In reference to the other sources of accidents in winding shafts, mention may be made of overwinding and mistaken signals. To prevent accidents from overwinding, it is best to fit the rope with a detaching-hook and to keep it in good order by oiling and cleaning at more frequent intervals than are stated in the special rules. The pulleys should also be at a good height, so that there may be from 15 to 20 feet of space between the pulleys and the cage-chains. Many old collieries are at a disadvantage in this respect, and consequently a detaching-hook is absolutely necessary. The writer knows of one colliery where there is only 8 feet of space between the detaching-hook when the cage is at bank and the ring to which the rope is detached. Under such conditions it is impossible to avoid occasional stoppages, but serious accidents seldom happen, which speaks volumes for the efficiency of that detaching-hook.

As to accidents from mistaken signals, which occasionally happen, all reasonable precautions for their prevention are stated in the special rules of every colliery. It seems probable that this class of accident will never entirely disappear because it is only human to make mistakes. Perhaps the commonest accident of this class is caused by the engineman taking the cage away while men are getting into it. On investigating such cases, it would seem that the old-fashioned rapper is the safest means of transmitting signals, as it is not so liable to go wrong as the electric bell. A very safe method of lowering and raising men is in use at a large colliery with which the writer is connected. At this place a special pit is set aside for the purpose of riding the workpeople, and is fitted with one large cage of two decks, capable of carrying 24 persons. Each deck is 6 feet in height, so that the workmen can stand upright, and the decks are entirely enclosed with sheet iron and fitted with doors. A guard or conductor continually travels with the cage, and he has entire charge of the signals. The special feature of the arrangement is the method of electric

signalling. By means of a copper cable running from the top to the bottom of the shaft, and passing vertically through the cage, signals can be transmitted from the cage to the engine-house. By such an arrangement the workmen are all in the cage, and closed in by doors before the signal is given to the engineman, and this signal is always given by the guard, who has entire charge. By means of batteries at the different seams, signals can be given from each seam to the cage which may be running in the shaft in order to let the guard know at what seam workmen are waiting to ascend. No signal can be given to the engineman except by the guard. At each seam there are two stages or platforms, so that the loading or unloading of the cage goes on simultaneously at both decks, thus avoiding the necessity of moving up the cage, which is a frequent cause of accident. Should anything go wrong with the cage when running in the shaft it can be instantly stopped by the occupants. This arrangement the writer considers to be a very excellent one. As will be readily seen, the men must be inside the cage before it is possible to signal it away. A heavy counterbalance also runs in the pit to give an uniform load and to steady the motion of the cage. The rope is provided with a detaching-hook, and the distance between the hook and the detaching-ring is 10 feet. The writer gives details of this arrangement, not only because of its safety, but because it is little known and therefore not much used.

The greatest number of shaft-accidents occur in sinking-pits, as might be anticipated. The *débris* is wound in kibbles generally without guides; the sides are unwalled for long distances; there is no protection to the sinkers in the bottom if anything falls from the sides, from the ascending kibble, or from the bank. Great care, of course, is always taken to steady the kibble before moving it away from the bottom of the pit, and to clean all loose stones from the sides and bottom of the kibble; also never to fully load it; and the sides of the pit also are timbered where the stone is not good. The greatest danger lies in things falling from the surface, consequently the pit-top must be well covered. An approved arrangement nowadays is to use a sliding-trolley, which runs upon rails and balks laid across the top of the pit. What the writer believes to be a safer arrangement than this is the Galloway folding-door. These folding-doors are at present being used at a sinking-pit which the writer has recently visited, and he thinks their merits deserve a little mention. A pair of strongly-hinged doors are fixed across the top of the pit, and they work in a stout framework. By means of an arrangement of weighted levers these doors can be opened and shut as required when *débris* or water is being drawn.

The advantage which they have over the trolley is the rapidity with which they can be shut. In case of the kibble being overwound, the doors can be shut in a sufficiently short time to prevent danger to the men in the shaft from anything falling down. Where the trolley is used it is very questionable whether this could be done. Of course in all sinking-pits it is best to use a detaching-hook, and thus reduce the probability of accidents from overwinding.

Explosives and Suffocation.—The number of deaths occurring from these causes is very small, amounting, as will be seen from official statistics, to less than 3 per cent. of the total. The writer does not therefore intend to deal with the subject in detail, but confines himself to one or two of its more important phases. The Coal Mines Regulation Act and the special rules give detailed instructions for the prevention of accidents from shot-firing, and the enforcement of these rules has doubtless prevented many accidents.

There is only one addition required to these very excellent rules to make them perfect, and that is a rule declaring shot-firing by electricity compulsory. This may seem to many engineers a needless expense; but when we remember that all shot-firing accidents occur when lighting the fuze, or when examining a shot that has missed fire, we cannot but come to the conclusion that the introduction of a shot-firing agent which entirely removes these dangers should be made compulsory. In firing by electricity, the workman is removed from 100 to 150 feet from the shot at the time that he fires it. If it should happen to miss-fire, he can disconnect the wires from the battery and at once examine the spot without danger; and added to this, is the fact that no unlocking of a safety-lamp is required. Nowadays, small batteries suitable for such work can be obtained at moderate cost, so that any expense incurred in their purchase and working would be inconsiderable when compared with the increased conditions of safety which had been obtained.

Suffocation by gases has in former years been the cause of many accidents. Sometimes a thoughtless workman has descended an old shaft or disused staple, and has been overcome by the stythe or carbonic acid gas accumulated therein. At other times an unexpected holing into old unventilated workings has liberated noxious gases, which have suffocated the unfortunate workman. Even where a borehole has been kept in advance, accidents have of recent years happened by neglecting to have the necessary appliances for preventing the inrush of gas and water

when holing. It would be going over well-known ground to review in detail the precautions to be used in such cases, but a word or two will not be out of place.

It is prudent to lower a light before descending any old shaft or staple which is unventilated. If the light be extinguished, the air is foul and needs renewing. A few buckets of water will generally be sufficient to do this. Water acts as an absorbent of the carbonic acid gas. Two or three shovelfuls of slaked lime will do even better than water, as slaked lime absorbs carbonic acid gas with great avidity. If, after these precautions, the light continues to burn when lowered, the workmen may then safely descend.

When approaching workings likely to contain gas and water, we are told by the Coal Mines Regulation Act that the workings approaching that place shall not exceed 8 feet in width, and that sufficient boreholes shall be kept in advance. It is best to drive two places well in front, and to connect these by frequent holings. It is also prudent to have, when possible, an energetic ventilation, so that when a holing is made the workmen are not so liable to be overcome by the sudden rush of gas which often precedes the water. Wooden plugs, suitable for stopping the hole, should be provided, and safety-lamps should alone be used. One or two spare safety-lamps should be constantly kept hanging a few feet back from the face to be used in case of accidents to the lamps in the face when the holing is made. When boring against high pressures of water it is best to bore through a sluice-valve fixed in a pipe at the entrance to the borehole. In case of holing, the valve can be turned and the flow of water or gas stopped. Quite recently the Burnside coal boring-machine and sluice-valve combined has been introduced for this work, and the writer believes that it has given very excellent results.

Tubs or Engine-planes.—A considerable number of accidents happen from these causes, amounting to nearly 12 per cent. of the total. The writer thinks that carelessness and sheer recklessness is responsible for most of these accidents. This is probably due to the fact that nearly all the persons employed in the moving of tubs are boys, and therefore naturally reckless. In almost every accident which has been caused by tubs, the poor fellow has been the victim of his own recklessness. A common form of accident, for instance, is caused by riding on sets of tubs hauled by engine-power and jumping on and off the tubs while in motion. This, of course, is extremely dangerous, and is a breach of the special rules, but it is often done, with more or less fatal results. The

most constant vigilance on the part of the officials should be directed towards stopping this practice, and whenever any one is found doing so he should be most severely punished. People must be prevented from committing suicide, and much of the Coal Mines Regulation Act is framed for that purpose.

Another class of accident on engine-planes is caused by winch-handles. The engineman by some mistake moves his engine at the same time as the boy is pulling a rope with the winch. The result is that the motion of the winch is suddenly reversed, and the handle flying round with great velocity very often strikes the boy on the head, with fatal results. A pawl should be fitted on to each winch, and it should always be put over before the handle is turned, but wherever accidents have occurred it has been found that the boy has neglected to use the pawl. Too much discipline cannot be exercised to make the boys use this simple precaution.

Tubs sometimes run amain on self-acting inclines and other steep places. At all such places stop-blocks, runaway switches, and drags are placed, or if not should be provided to stop this running amain, but when these are not used accidents occur. It is generally by not using the arrangements provided that accidents from this cause also happen. The writer can only advise officials to use the strictest discipline in all these cases, and to dismiss all persons who are found neglecting to use the apparatus provided for saving life.

On horse-roads also we sometimes have accidents. Drivers of ponies get fast between the tub and the side, or the tub and the roof, and are crushed. In mining operations, in thin coal-seams especially, the roads are unavoidably low and small. We make our main roads spacious and large in every way, but for economic reasons we cannot pretend to make the temporary branch-roads of such large dimensions. In such places, the driver or pony-putter has to crouch down on the limbers in order to be safe. Occasionally he forgets to do so and, raising his head, receives an injury. This appears to be one of the permanent dangers attendant on mining operations.

Accidents on the Surface.—It might be said that accidents on the surface about mines do not properly belong to this subject as they do not occur in the mine itself, but as they are included in the statistics of accidents already given, the writer will simply mention them. The number of accidents occurring on the surface is in itself very considerable, amounting, in the year 1893, to 11·32 per cent. of the total. As might

be imagined, the greater number of these occur on and about the sidings of the pit. The traffic of the locomotives removing the mineral from the sidings, and the shunting and lowering of waggons under the screens necessarily cause an element of danger which cannot be avoided. Many people have been killed by being crushed between a waggon and a pillar or stay while lowering waggons to the screens. Precautions are being taken to remedy this class of accident in many places by the removal of these supports, the screens being suspended by strong steel-girders. These girders, although they have a long span, do not need any central stay or support, and therefore leave the space between the lines of way perfectly clear.

Other accidents on the surface are of a very miscellaneous kind—falls from scaffolding, blood poisoning from wounds, etc. The writer does not propose to remark upon them, as they appear to be accidents which cannot altogether be avoided.

The writer has briefly dealt with the commonest forms of accidents, and has endeavoured to give the results of the experience of practical men on their prevention. He has written as a student for students, and has relied almost entirely on the knowledge which practical experience and observation have afforded him. He has avoided descriptions of any instrument or machine for the prevention of accidents, such as can be found in text-books, in the belief that this was not the information desired by the promoters of the present essay. He concludes with the hope that these pages on this most important subject will be received in an indulgent spirit, as coming from one who is as yet but a novice in the great profession of mining engineering.

Mr. THOS. DOUGLAS (President of the North of England Institute of Mining and Mechanical Engineers), then took the chair, and said that he had wished to be present at the first Students' Meeting held in connexion with The Federated Institution of Mining Engineers. When he served his apprenticeship, in 1845, the students could imagine how difficult it was for a young man to obtain information. At that time no facilities were afforded for visits to collieries which were now so freely accorded. While now, they had the advantages which he had detailed in his recent presidential address to the members of the North of England Institute of Mining and Mechanical Engineers. He had always endeavoured, as far as

he had the opportunity, to give his students towards the end of their apprenticeship some amount of charge, even though they might not be remunerated for it. This was not done when he was an apprentice, but he was sure he was speaking to many students, drawing near the end of their apprenticeship, who would agree with him that a little responsibility placed upon them would be very valuable in giving them practical experience in their profession.

There were many details of colliery management which could be made the subject of legislative enactment, but those interested in the management of mines must use their individual intelligence in formulating ordinary working detailed arrangements. The Legislature could not (and it was not desirable that it should) particularize in detail what the manager should do under the variety of circumstances which occurred in individual mines.

He was glad to see that Mr. Kirkup had written a very useful paper upon "The Prevention of Accidents in Mines," and he ventured to think that Mr. Kirkup had acquired a considerable amount of information in his preliminary studies.

He felt anxious that the first meeting of students should be successful, and he hoped that it would prove of value and lead to further meetings.

Mr. H. E. MITTON said that the death rate from explosions from 1882 to 1893 in the Midland inspection district was 0·6 per 1,000 persons employed per annum, and considering that over 21,000,000 tons were raised per annum, this showed the improved conditions of working prevailing in that district. Mr. Kirkup referred to collieries ventilated by a furnace, in which the quantity of air, as measured in the main intake-airways, was 480,000 cubic feet per minute. But he had not mentioned the depth of the pit.

Mr. KIRKUP—1,500 feet.

Mr. MITTON, continuing, said with regard to testing lamps, he was acquainted with a colliery where there was a safety-lamp testing-box in the lamp-cabin, and before any lamp was sent into the mine it was tested with gas, and any defect at once discovered. He thought that it was a bad principle in mines ventilated by furnaces, especially in fiery mines, to allow the return air-current to pass over the furnace. He suggested that a dumb-drift should be used. He did not see how blasting-powder could be dispensed with in mines, until something could be found to take its place which had not the shattering effect of the high explosives. He agreed with Mr. Kirkup in his remarks about compulsory spragging; the words "where they are required" should certainly be omitted from

general rule 22. Mr. Kirkup had omitted to mention the use of reflectors as a method of increasing the light of safety-lamps when examining the roof and sides. A Marsaut lamp used by Mr. A. H. Stokes had a flat wick ($\frac{7}{16}$ inch wide), burning colza oil, and comparing it with the standard candle without a reflector, the illuminating-power was shown to be 0·47 of a standard candle; with a white enamelled reflector it was increased to 0·94, showing the great advantage due to the use of the reflector. There was a special rule in Derbyshire with regard to drawing timber, enforcing the use of a "ringer and chain"; and he thought no timber should be drawn without it. It was an excellent rule not to allow the cage, when at rest, to hang in the same spot, especially when head-stocks were uncovered. He (Mr. Mitton) thought that every mine should adopt the use of detaching-hooks whether there were 3 or 20 feet between the pulley and the cage-chains. And in addition to detaching-hooks, he suggested that a pair of props or keps, similar to those used for resting the cage on the bank, might be fixed in the head-stocks in such a position that if the key-plate of the detaching-hook failed to catch, the cage would fall upon the props. One of the most frequent and dangerous sources of accidents on the surface was due to workmen being crushed between waggons and the supporting columns of the screens. He thought no shunter should be employed who was not more than 18 years old.

Mr. R. O. Brown said Mr. Kirkup in the opening paragraph of his essay stated that the most important duty which we have to perform is to see that all the different operations of mining are carried out in as safe a manner as possible, and that the Coal Mines Regulation Act and rules are strictly adhered to. This, of course, was most important, but there was also the higher obligation of preventing accidents on humanitarian grounds, apart from the mere duty of carrying out the Act and rules.

In the essay, the number of deaths is taken as the most reliable datum for the comparison of the various classes of accidents in each year. He suggested that all accidents (fatal and non-fatal) should be taken into account. In Northumberland and Durham (according to the report of the working of the Permanent Relief Fund for 1894) there were 166 fatal accidents, 217 persons were permanently disabled, and 17,000 work-people suffered from other non-fatal accidents.

Much could be said in favour of and against compulsory timbering; but would compulsory timbering have prevented some of the accidents quoted in the paper? The stone weighed 4 tons and was 6 feet in diameter,

and unless the timbering was very closely placed there would probably be only one prop under it, and this perhaps at its edge, so that the accident would probably have occurred under any circumstances. Strict supervision by the under-manager and overman, and a severe penalty for anyone removing timber set by the deputy, would help in a great degree to reduce the number of accidents by falls of stone.

Mr. Kirkup said, and rightly so, that one of the chief causes of broken ropes is internal corrosion. This is sometimes due to the rope-oil used. Some of these so-called oils contain unboiled tar, and possibly, under certain conditions, the oil and water together may set up a chemical action upon the wires which neither alone would do. Sharp-edged cleats and nails on rope-drums are often the cause of broken ropes, and should be carefully avoided. Mr. Kirkup, in speaking of safety detaching-hooks, mentioned a case where there was only 3 feet between the detaching-hook and the cage, which Mr. Kirkup says "speaks volumes for the efficiency of that detaching-hook." He thought that these satisfactory results were more particularly due to the carefulness of the engine-man and not especially to the hook.

Nothing was said about ambulance work in this paper. It could hardly be said to prevent accidents, but it minimized their consequences, and a knowledge of first aid to the injured should be insisted upon in the case of officials and encouraged among the workmen.

Mr. W. D. HARBIT, referring to shot-firing accidents, said that Mr. Kirkup was wrong in stating that all shot-firing accidents occurred when lighting the fuze, or when examining a shot that had missed fire. With reference to using old winding-ropes for hauling purposes, it would be interesting to know of any collieries where this practice was adopted.

Mr. R. O. BROWN said that old winding-ropes were frequently used for hauling purposes.

Mr. A. NOBLE said that old winding-ropes could be and were used for hauling from dip drifts.

Mr. W. R. BELL thought that Mr. Kirkup was in error in saying that the return airways were not frequently travelled—the special rules in force in this district, provided that the overman, deputy, and other officials shall "travel from time to time the return air-courses."

Mr. A. NOBLE said that the system of cavilling in vogue in this district might also be a source of accident, because workmen after becoming used to a certain seam, were moved to another seam—where perhaps another system of working was in force.

Mr. T. E. PARRINGTON thought that Mr. Kirkup was in error in attributing blown-out shots in many cases to the use of short lengths of stemming. He (Mr. Parrington) had always found and heard that from 5 to 7 inches of good stemming was sufficient.

Mr. E. FAWCETT, referred to the remarks in the paper upon boring against accumulations of water, and the requirements of the Coal Mines Regulation Act that the workings approaching such places should not exceed 8 feet in width. Did Mr. Kirkup think that a hole 15 feet in advance was sufficient in all cases? Referring to Mr. Mitton's remarks as to the use of a pair of keps below the pulleys, he (Mr. Fawcett) thought that the suggestion was of value, as he knew of one case where the cage went up to the pulleys, the shackle below the detaching-hook broke, and the cage fell to the bottom of the shaft.

Mr. AUSTIN KIRKUP, referring to Mr. Mitton's objection to allowing return air-currents to pass over the furnace, said that was only allowed in cases where such air was free from fire-damp. Air from dangerous workings was carried into the shaft by means of one or more dumb-drifts. He had not had much experience as to the shattering effect of high explosives, but he believed such nitrate-of-ammonium explosives as roburite did not shatter the coal so much as nitro-glycerine compounds. The workmen sometimes used reflectors when travelling in or out of the mine, but when they got to their working-places the reflectors were removed, so as to secure an all-round illumination in preference to a stronger light on one particular place, but no doubt for the examinations of roof the use of a reflector would be an advantage. The "ringer and chain," or "dog and chain" was in use in this district, but in many cases the timber-drawers said that it was of no use; all props could not be drawn by means of the ringer and chain, large props when set into a soft coal bottom and wedged against the top were rather awkward to deal with, and had generally to be chopped or "whistle-ended" before they could be removed. Mr. Mitton also referred to the desirability of making the use of detaching-hooks compulsory, but there were cases where it would not be practicable to employ them without increasing the height of the pulley-legs; he referred particularly to one case where a four-decked cage measuring 18 feet high was in use, and it was necessary at times to lift the cage above the flat-sheets to hang a kibble below it, and if a detaching-hook were used this could not be done. In the great majority of cases, however, detaching-hooks were a great advantage.

Mr. Brown had referred to the question of compulsory timbering, and with reference to the fall of stone mentioned in the paper, said that if

timber had been used the stone might still have fallen, as there would probably only have been a single prop under it. But even in that case it would have given warning, and it was probable that the stone would have been tilted to one side, and would have allowed the workman to spring out of the way. The question of ambulance ought certainly to have been mentioned in the paper, and he regretted that such an important matter had been omitted.

With regard to Mr. Harbit's remarks, there would be no waiting of miss-fires if shots were electrically fired. If the shot did not go off at once, the wires could be disconnected, and the workman could approach the shot in safety.

As regards Mr. Bell's facetious remark, as to the return airways not being used for travelling, he (Mr. Kirkup) referred in his paper to the ordinary travelling in and out by the workmen.

Mr. Parrington remarked upon the length of stemming, but he (Mr. Kirkup) had always been taught that the liability to blown-out shots was decreased as the length of stemming was increased, although theoretically 8 would be as good as 24 inches.

The CHAIRMAN said Mr. Kirkup stated that at his colliery there was little or no blasting either in stone or coal. It would be interesting to know the character of the stone and coal, and how it was dealt with, for in many cases it was not gannister exactly, but a very hard sandstone, difficult to deal with. The Chairman said as there were no further remarks offered he had pleasure in presenting to Mr. Kirkup the books which had been awarded to him for the prize essay.

Mr. KIRKUP expressed his sincere thanks to the Institution for the valuable present of books awarded to him, to Mr. Douglas for his kind remarks upon his paper, and to his fellow-students for the kindly way in which they had listened to his paper. It had been a great pleasure to him to prepare the paper, and, as the Chairman observed, it had also been a great source of instruction. He hoped this meeting would be by no means the last of its kind, and he hoped that next year some student now present would occupy the position that he held that day.

The CHAIRMAN moved, and Mr. F. KIRKUP seconded, a resolution that a hearty vote of thanks be accorded to the North of England Institute of Mining and Mechanical Engineers for arranging the present meeting, and to the Wearmouth Coal Company, Limited, and to the Hetton Coal Company, Limited, for allowing the students to visit their respective collieries.

Mr. R. O. BROWN moved, and Mr. NESBIT seconded, that a cordial vote of thanks be given to the Chairman for his services that day.

The meeting then closed.

The Wearmouth and Elemore collieries were, by kind permission of the owners, open for inspection, during the course of the meeting on August 14th and 15th, 1895.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, AUGUST 3RD, 1895.

MR. THOMAS DOUGLAS, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council at their meetings on July 20th and that day.

ELECTION OF OFFICERS.

The PRESIDENT appointed Messrs. J. T. Todd, W. R. Dakers, L. Thursby, and W. E. Nicholson as scrutineers of the balloting papers for the election of officers for the year 1895-96. These gentlemen afterwards reported the result of the ballot as follows:—

PRESIDENT.

Mr. T. DOUGLAS.

VICE-PRESIDENTS.

Mr. W. ARMSTRONG, Sen.	Mr. GEORGE MAY.
Mr. C. BERKLEY.	Mr. J. G. WEEKS.
Mr. J. L. HEDLEY.	Mr. W. O. WOOD.

COUNCIL.

Mr. W. ARMSTRONG, Jun.	Mr. J. H. MERIVALE.
Mr. H. AYTON.	Mr. J. MORISON.
Mr. E. BAINBRIDGE.	Mr. H. PALMER.
Mr. W. C. BLACKETT.	Mr. A. M. POTTER.
Mr. J. R. CRONE.	Mr. R. ROBINSON.
Mr. W. H. HEDLEY.	Mr. T. O. ROBSON.
Mr. A. C. KAYLL.	Mr. F. STOBART.
Mr. H. LAWRENCE.	Mr. S. TATE.
Mr. C. C. LEACH.	Mr. W. H. WOOD.

Mr. J. A. RAMSAY (Durham) moved a vote of thanks to the President, Vice-Presidents, Council, and Secretary for their services during the past year.

Mr. DAVID BURNS (Carlisle) seconded the vote of thanks, which was cordially adopted.

The PRESIDENT said that this meeting terminated his first year of office, and he desired to thank the members very much for their kindness to him during that period. He was very glad that the attendance of members at the General Meetings had been so large, and it was a great encouragement to know that the papers communicated at the meetings were so largely approved.

The PRESIDENT moved, and Mr. STEAVENSON seconded, that a vote of thanks be given to the scrutineers for their services, which was agreed to.

REPRESENTATIVES ON THE COUNCIL OF THE FEDERATED INSTITUTION OF MINING ENGINEERS.

Mr. J. B. SIMPSON moved, and Mr. R. T. SWALLOW seconded, that the following gentlemen be elected as the representatives of this Institute on the Council of The Federated Institution of Mining Engineers for the ensuing year:—

Mr. W. ARMSTRONG, Jun.
Mr. E. BAINBRIDGE.
Mr. T. W. BENSON.
Mr. W. C. BLACKETT.
Mr. T. FORSTER BROWN.
Mr. WM. COCHRANE.
Mr. JOHN DAGLISH.
Mr. T. DOUGLAS.
Mr. T. E. FORSTER.
Mr. JEREMIAH HEAD.
Mr. J. L. HEDLEY.
Mr. A. C. KAYLL.
Mr. C. C. LEACH.
Mr. GEORGE MAY.
Mr. J. H. MERIVALE.
Mr. J. MORISON.
Mr. H. PALMER.
Mr. M. W. PARRINGTON.
Mr. A. M. POTTER.
Mr. T. O. ROBSON.
Mr. A. L. STEAVENSON.
Mr. S. TATE.
Mr. J. G. WEEKS.
Mr. R. L. WEEKS.

The motion was agreed to.

Mr. J. H. MERIVALE moved that a vote of thanks be accorded to the representatives of the Institute on the Council of The Federated Institution of Mining Engineers during the past year.

Mr. J. B. SIMPSON seconded the resolution, which was cordially agreed to.

The SECRETARY read the Annual Report of the Council and of the Finance Committee as follows:—

ANNUAL REPORT OF THE COUNCIL, 1894-95.

The following table shows the numbers of members of various classes during a few recent years:—

	August 1st.		
	1893.	1894	1895.
Honorary Members...	25	26	26
Members	565	624	717
Associate Members	47	53	67
Associates	47	68	67
Students	34	20	36
Subscribing Collieries, etc.	22	22	23
Totals	740	813	936

The steady increase of the membership is a matter of congratulation. The members are, however, desired, at all times, to promote its claims and advantages and to extend the membership, which is still below the figures of a few years ago, viz.:—Honorary Members, 23; Members, 792; Students, 142; and Subscribing Collieries, etc., 14; a total of 971 of all classes.

The initiation of the class of Associates, consisting of persons occupying subordinate positions in engineering, has proved very successful, and has materially increased the roll of members.

The revision of the composition payable in lieu of the annual subscription has been approved, as shown by the number of members who have so compounded. The Council will invest the amounts so received, as suitable investments are suggested to them.

The Council regret that no papers have been received from Students and Associates during the course of the year.

The additions to the library by donations, exchange, purchase, etc., have been:—

Bound volumes	248	
Pamphlets, reports, etc.	314	
A total of	562	titles.

And it is probable that the library now contains 6,914 volumes, and 1,171 unbound pamphlets. A card catalogue is now being prepared, and should render the books more readily available to members.

The library (including the books and weekly engineering papers) is available to members in the vicinity, from 10 a.m. to 5 p.m. daily, and those residing at a distance may make use of the books by communication with the Secretary.

It is a matter of regret that some of the files of publications have been rendered incomplete by the neglect of members to return borrowed books to the library, and it is earnestly desired that members will return the missing volumes.

The library could be rendered more valuable, if members would present volumes, etc., which they can spare from their own libraries. Members would also render a real service to the profession by bequeathing books, reports, plans, etc., to the library, where they would be preserved, be available for reference, and maintain the memory of the donor.

The Wood Memorial Hall, Lecture Theatre, etc., have been kept in good repair.

The reservation of a reading-room has been under consideration, and the Council trust that satisfactory arrangements to that effect will be shortly completed.

An arrangement has been made with the Literary and Philosophical Society of Newcastle-upon-Tyne, whose premises are connected with the library of the Institute, by which the door between the libraries of the two societies is opened daily, and the members of either society are permitted (on producing a members pass) to refer to the books in the library of the other society.

Five volumes of the *Sinkings and Borings* (A to T) have been issued, and the remaining volumes will be published at early dates.

The prices of the *Transactions* and other publications of the Institute have been recently reduced, and members are recommended to complete their sets before the stock is exhausted.

Arrangements are being made in order that papers of interest to Indian and Colonial members may be locally read and discussed, and it is desired that the members will endeavour to ensure the success of such local meetings.

The Explosives Committee have continued their investigations as to the merits of the various flameless explosives at their weekly meetings. The first portion of their *Report* has been issued, and they anticipate being able to issue the second portion of their *Report* before the end of

the year. The Council have offered the use of the entire plant for testing explosives for use in mines to the Secretary of State for the Home Department.

The report of the Committee on Mechanical Ventilators is approaching completion, and will be issued during the current year to the members.

Mr. J. H. Merivale has been reappointed to represent the Institute at the Conference of Corresponding Societies of the British Association for the Advancement of Science at Ipswich in September next.

Mr. John Daglish has been reappointed on behalf of this Institute as a governor of the Durham College of Science, Newcastle-upon-Tyne. Mr. W. Cochrane has been appointed as the representative of the Institute on the Science and Art Committee, and Mr. J. H. Merivale on the Scholarships Committee of the Northumberland County Council.

The Federated Institution of Mining Engineers has now completed its sixth year, during which general meetings have been held at Newcastle-upon-Tyne on September 5th, 6th, and 7th, 1894; at Birmingham on February 12th and 13th, 1895; and at London on May 30th and 31st and June 1st, 1895. The meeting held in this district was well attended, and the best thanks of the Institute are due to the Committee who made the arrangements, and to all those who by their services contributed to the holding of that successful meeting.

Prizes of books have been awarded to the writers of the following papers communicated to the members during the year 1893-94:—

"A Contribution to our Knowledge of Coal-dust. Part II." By Dr. P. Phillips Bedson.

"A Contribution to our Knowledge of Coal-dust. Part III." By Dr. P. Phillips Bedson and Mr. W. McConnell, Jun.

"The Combustion of Oxygen and Coal-dust in Mines." By Mr. W. C. Blackett.

"History and Description of the Greenside Silver Lead Mine, Patterdale." By Mr. W. H. Borlase.

"The Choice of Coarse and Fine-crushing Machinery and Processes of Ore Treatment." By Mr. A. G. Charleton.

"The Ghorband Lead-mines, Afghanistan." By Mr. A. L. Collins.

"Note on the Antimony Deposit of El Altar, Sonora, Mexico." By Mr. Edward Halse.

"Note on the Occurrence of Mercury at Quindiú, Tolima, U.S. Colombia." By Mr. Edward Halse.

"Mining Explosives: Their Definition as Authorized under the Explosives Act, 1875." By Mr. A. C. Kayll.

"Miss-fires." By Mr. J. D. Kendall.

"Singareni Coal-field, Hyderabad, India." By Mr. J. P. Kirkup.

"Corliss-engined Fan at Seghill Colliery." By Mr. C. C. Leach.
"Historical Sketch of the Whitehaven Collieries." By Mr. R. W. Moore.
"Magnetic Declination and its Variations." By Prof. H. Stroud.
"Minerals and Mining in Tasmania." By Mr. A. P. Wilson.

The papers communicated to the members during the year have been as follows:—

"The Brunsviga Calculating-machine." *Anon.*
"Coal-mines Regulation Bill, 1895." By Mr. M. Walton Brown.
"The Brunck Coke-oven and System for the Recovery of Bye-products." By Dr. R. Brunck.
"Sinking with Rock-drills." By Mr. Frank Coulson.
"The Semet-Solvay Coke-oven." By Mr. John H. Darby.
"Presidential Address." By Mr. T. Douglas.
"The Effect of an Obstruction in the Air-way of a Mine." By Mr. T. L. Elwen.
"Magnetic Declination in Mines." By Mr. James Henderson.
"Report of the Proceedings of the Flameless Explosives Committee. Part I.—Air and Combustible Gases." By Mr. A. C. Kayll.
"The Working of Hæmatite in the Whitehaven District." By Mr. J. M. Main.
"The Mining of the Softer Ores of Furness." By Mr. H. Mellon.
"Improvements in Brick-kilns." By Mr. R. W. Moore.
"The Extension of the West Cumberland Coal-field, Southward and Northward under the St. Bees Sandstone." By Mr. R. Russell.
"Electric Transmission of Power." By Mr. Alexander Siemens.
"Saving of Life from After-damp, Smoke, or Fumes in Mines." By Mr. Simon Tate.
"Engineering Heliography, or the Sun-print Copying of Engineering Drawings." By. Mr. B. H. Thwaite.
"Experiments with Explosives." By Mr. Winkhaus.
"British Guiana Gold-fields." By Mr. E. P. Wood.
"The Murton Coal-washer." By Mr. W. O. Wood.

In conclusion, the Council desire to impress upon the members that the success of the Institute in the future is entirely dependent upon a continued increase of the membership, so as to meet the considerable expenses incurred by its connexion with The Federated Institution of Mining Engineers.

REPORT OF THE FINANCE COMMITTEE.

The total income for the year amounted to £2,232 15s. 8d.; deducting the sum of £131 2s. 0d., subscriptions of new life members, and £97 13s. 0d., subscriptions paid in advance, leaves £2,004 0s. 8d. as

the ordinary income for the year. The ordinary income for the previous year, arrived at in the same manner, was £1,841 10s. 7d., showing an increase during this year of £162 10s. 0d.

The amount of subscriptions now in arrear, excluding the current year, is £71 8s. 0d.

The total expenditure amounted to £2,010 18s. 1d., an increase of £101 1s. 5d. The principal items contributing to this increase are:—Contributions to The Federated Institution of Mining Engineers, owing to the increased number of members, £39 11s. 5d.; postages, £10 12s. 2d.; printing (including the *Report* of the Proceedings of the Flameless Explosives Committee), £45 12s. 9d.; preparation of library card catalogue, £40 0s. 0d.; law charges, £10 3s. 8d.; and expenses of the meeting of The Federated Institution of Mining Engineers in this district, £44 9s. 1d. There is a decrease of £43 11s. 0d. in the expenses of the Flameless Explosives Committee; and £27 15s. 9d. in the cost of furnishing.

The Council having reduced the price to members of certain volumes of the *Transactions*, a reduction has been made in the value shown in the balance sheet.

August 3rd, 1895.

The PRESIDENT said that there were many matters in the Annual Report and Accounts which were very satisfactory. In the first place the membership had increased, and the papers communicated to the members had been numerous and of great interest. He regretted that no papers had been received from Students or Associates during the course of the year, in response to the invitation of the Council, for the purpose of being read and discussed at meetings of Students and Associates. The first meeting of the Students of The Federated Institution of Mining Engineers had been arranged to be held in this district, and he hoped that they would take advantage of it in as large numbers as possible, in order that the Council might be encouraged to hold similar meetings in the future. He had pleasure in moving the adoption of the reports of the Council and of the Finance Committee.

Mr. J. B. SIMPSON seconded the resolution. which was unanimously adopted.

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND FOR THE YEAR ENDING

	£ s. d.	£ s. d.
July 21st, 1894.		
To Balance at Bankers	457 10 0	
„ „ in Treasurer's hands	84 12 3	
„ Outstanding Amounts for Authors' Excerpts	10 16 11	
July 21st, 1895.		552 19 2
To Dividend of 7½ per cent. on 134 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd., for the year ending June, 1895	201 0 0	
„ Interest on Investments with the River Tyne Commissioners	53 3 8	
		254 3 8
To SUBSCRIPTIONS FOR 1894-95 AS FOLLOWS:—		
508 Members ... ... @ £2 2s.	1,066 16 0	
1 Member ... ... @ £1 1s.	1 1 0	
37 Associate Members ... ... @ £2 2s.	77 14 0	
56 Associates ... ... @ £1 1s.	58 16 0	
18 Students ... ... @ £1 1s.	18 18 0	
97 New Members ... ... @ £2 2s.	203 14 0	
6 New Members (Life Compositions)	131 2 0	
19 New Associate Members ... ... @ £2 2s.	39 18 0	
12 New Associates ... ... @ £1 1s.	12 12 0	
22 New Students ... ... @ £1 1s.	23 2 0	
	1,633 13 0	
To SUBSCRIBING COLLIERIES, VIZ.:—		
3 @ £10 10s.	31 10 0	
3 @ £6 6s.	18 18 0	
5 @ £4 4s.	21 0 0	
10 @ £2 2s.	21 0 0	
1 New Subscriber @ £2 2s.	2 2 0	
	94 10 0	
To Donations	4 4 0	
	1,732 7 0	
Less—Subscriptions for current year paid in advance at the end of last year...	56 14 0	
	1,675 13 0	
To Arrears received	139 13 0	
	1,815 6 0	
„ Subscriptions paid in advance during current year ...	97 13 0	
		1,912 19 0
„ Sale of Publications		65 13 0
		£2,785 14 10

INSTITUTE OF MINING AND MECHANICAL ENGINEERS. CR.
JULY 31ST, 1895.

July 21st, 1895.	£	s.	d.	£	s.	d.
By Printing and Stationery				205	15	4
„ Books for Library	48	13	0			
„ Prizes for Papers	25	4	0			
„ Incidental Expenses	63	2	9			
„ Postages	67	17	7			
„ Sundry Accounts	7	8	4			
„ Travelling Expenses	14	12	6			
„ Salaries	150	0	0			
„ Clerks' Wages	147	2	8			
„ Reporter's Salary	16	16	0			
„ Rent	94	13	10			
„ Rates and Taxes	22	8	3			
„ Insurance	12	8	4			
„ Furnishing, Repairs, etc.	80	3	6			
„ Coals, Gas, Electric Light, and Water	39	15	3			
„ Library Card Catalogue	40	0	0			
„ Law Charges	10	3	8			
„ Printing and Stationery	0	8	0			
„ Translation of Papers	4	10	0			
„ Newcastle Meeting of The Federated Institution of Mining Engineers	44	9	1			
				889	16	9
„ Fan Committee	0	11	0			
„ Explosives Committee	38	5	1			
„ British Association Meeting—Delegate's Expenses ...	5	0	0			
				43	16	1
By The Federated Institution of Mining Engineers—Subscriptions	879	14	10			
Less—Amounts paid by Authors for Excerpts ...	8	4	11			
				871	9	11
				2,010	18	1
By Balance at Bankers	685	7	10			
„ „ in Treasurer's hands	84	12	3			
„ Outstanding Amounts for Authors' Excerpts	4	16	8			
				774	16	9
				£2,785	14	10

I have examined the above account with the Books and Vouchers relating thereto, and certify that, in my opinion, it is correct.

JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,
August 2nd, 1895.

Dr.					The Treasurer in Account					
					£	s.	d.	£	s.	d.
To 624 Members, 30 of whom are Life Members.										
594	594	@ £2 2s.	...	...	...			1,247	8	0
To 53 Associate Members, 5 of whom are Life Members.										
48	48	@ £2 2s.	...	...	...			100	16	0
To 68 Associates		@ £1 1s.	...	...	...			71	8	0
To 20 Students, 1 of whom transferred to List of Members.										
19	19	@ £1 1s.	...	...	...			19	19	0
To 22 Subscribing Collieries	...	...	...	...	...			96	12	0
To 97 New Members		@ £2 2s.	...	...	...			203	14	0
To 6 New Members (Life Compositions)			...	...	...			131	2	0
To 19 New Associate Members @ £2 2s.			...	...	...			39	18	0
To 12 New Associates		@ £1 1s.	...	...	...			12	12	0
To 22 New Students		@ £1 1s.	...	...	...			23	2	0
To 1 New Subscriber ...	...	...	...	...	...			2	2	0
To Donations	...	...	...	...	...	...	...	4	4	0
								1,952	17	0
To Arrears, as per Balance Sheet 1893-94	...	...	...		192	3	0			
Add—Arrears considered irrecoverable, but since paid	...				18	18	0			
								211	1	0
								2,163	18	0
To Subscriptions Paid in Advance	...	...	...	...	...		...	97	13	0
								£2,261	11	0

WITH SUBSCRIPTIONS, 1894-95. CR.

		PAID. £ s. d.	UNPAID. £ s. d.
By 508 Members, paid	@ £2 2s.	1,066 16 0	.....
By 1 „ paid	@ £1 1s.	.....	1 1 0
By 85 „ unpaid	@ £2 2s.	.....	178 10 0
594			
By 37 Associate Members, paid	@ £2 2s.	77 14 0	.....
By 11 „ „ unpaid	@ £2 2s.	.....	23 2 0
48			
By 56 Associates, paid	@ £1 1s.	58 16 0	.....
By 11 „ unpaid	@ £1 1s.	.....	11 11 0
By 1 „ dead		.....	1 1 0
68			
By 18 Students, paid	@ £1 1s.	18 18 0	.....
By 1 „ unpaid	@ £1 1s.	.....	1 1 0
19			
By 21 Subscribing Collieries, paid		92 8 0	.....
By 1 „ „ unpaid		.....	4 4 0
22			
By 97 New Members, paid	@ £2 2s.	203 14 0	.....
By 6 New Members (Life Compositions), paid		131 2 0	.....
By 19 New Associate Members, paid ...	@ £2 2s.	39 18 0	.....
By 12 New Associates, paid	@ £1 1s.	12 12 0	.....
By 22 New Students, paid	@ £1 1s.	23 2 0	.....
By 1 New Subscriber		2 2 0	.....
By Donations		4 4 0	.....
		1,732 7 0	220 10 0
By Arrears		139 13 0	71 8 0
By Subscriptions paid in advance		97 13 0	.....
		1,969 13 0	291 18 0
			1,969 13 0
			£2,261 11 0

General Statement, July 21st, 1895.

Liabilities.	£	s.	d.	£	s.	d.
Subscriptions paid in Advance during the year	97	13	0			
„ carried over from previous year	2	2	0			
				99	15	0
Capital				9,159	17	11
				£9,259	12	11

I have examined the above account with the books and vouchers relating thereto, and certify that, in my opinion, it is correct. The Share Certificates and Bonds have been produced to me.

JOHN G. BENSON,
Chartered Accountant.

Newcastle-upon-Tyne,
August 2nd, 1895.

Assets.	£	s.	d.	£	s.	d.
Balance of Account at Bankers	685	7	10			
„ in Treasurer's hands	84	12	3			
Outstanding amounts for Authors' Excerpts ...	4	16	8			
				774	16	9
134 Shares of £20 each in the Institute and Coal Trade Chambers Co., Ltd.	.....			2,680	0	0
Invested with River Tyne Commissioners ...	.....			1,500	0	0
Arrears of Subscriptions	.....			291	18	0
Value of 499 Bound Volumes of Transactions, @ 7s. 6d.	187	2	6			
„ 4,396 Sewn do., @ 5s.	1,099	0	0			
„ 2,398 Unbound Parts, @ 6d.	59	19	0			
„ 77 Copies of Mr. T. F. Brown's Map, @ 2s. 6d.	9	12	6			
„ 368 Copies of Index, Vols. 1-25, @ 6d.	9	4	0			
„ 846 Copies of Catalogue of Fossil Plants, @ 1s.	42	6	0			
„ 749 Copies of Fossil Illustrations, @ 2s. 6d.	93	12	6			
„ 1,500 Copies of Borings and Sinkings (Vol. I. in Sheets) @ 1s.	75	0	0			
„ 263 Do., Vol. I., sewn, @ 2s. 6d. ...	32	17	6			
„ 297 Do., Vol. II., „ @ 2s. 6d. ...	37	2	6			
„ 308 Do., Vol. III., „ @ 2s. 6d. ...	38	10	0			
„ 412 Do., Vol. IV., „ @ 2s. 6d. ...	51	10	0			
„ 343 Do., Vol. V., „ @ 2s. 6d. ...	42	17	6			
„ 242 Copies of Library Catalogue, @ 6d.	6	1	0			
„ 283 Copies of French Commission Report on Explosives in parts, @ 6d. ...	7	1	6			
„ 9 Do., Bound, @ 3s.	1	7	0			
„ 1,184 Copies of Report of the Flameless Explosives Committee (Parts 1 & 2.) @ 4d.	19	14	8			
				1,812	18	2
„ Office Furniture and Fittings ...	450	0	0			
„ Books and Maps in Library	1,750	0	0			
				2,200	0	0
				£9,259	12	11

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. CHARLES JOHN GRAY ALLAN, Gunpowder Works Manager, Electric House, West Calder, N.B.

Mr. WILLIAM ARCHER, Colliery Manager, Victoria Garesfield, Lintz Green, Co. Durham.

Mr. EDGAR ARTHUR ASHCROFT, Electrical Engineer and Metallurgist, De Vere Residential Hotel, De Vere Gardens, Kensington Palace, London, W.

Mr. PHILIP BOLAM, Colliery Manager, North Walbottle Colliery, Newcastle-upon-Tyne.

Mr. J. BUGLAS, Colliery Manager, Stobswood, via Acklington, Northumberland.

Mr. FRANK HAWTHORN BURN, Colliery Owner, Westcliffe, Gosforth, Newcastle-upon-Tyne.

Mr. ARTHUR C. CLAUDET, Metallurgical Chemist, 6 and 7, Coleman Street, London, E.C.

Mr. FRANK CROUDACE, Mining Engineer, Lambton Collieries, Newcastle, New South Wales.

Mr. MARK FORD, Manager, Sherburn Colliery, near Durham.

Mr. ARTHUR GOLDSWORTHY, Mining Agent, Linares, Provincia de Jaen, Spain.

Mr. JOHN CHARLES HALL, Colliery Manager, Pegswood Colliery, near Morpeth.

Mr. WHELDON HEPBURN, Manager, Littletown Colliery, near Durham.

Mr. WILLIAM TAYLOR HESLOP, Colliery Manager, Haltwhistle, Northumberland.

Mr. MATTHEW HENRY KELLETT, Assistant Manager, Ivy Terrace, South Moor, Chester-le-Street.

Mr. THOMAS KIDD, Jun., Land and Mine Surveyor, Linares, Provincia de Jaen, Spain.

Mr. GEORGE CRAIG LAMBE, Manager of Engineering Works, Merrington Iron Works, Spennymoor, Co. Durham.

Mr. SAMUEL WARREN PRICE, Mining Engineer and Surveyor, 25, Lochaber Street, Cardiff.

Mr. ROBERT RICHARDSON, Colliery Manager, Blaydon Main Colliery, Blaydon-upon-Tyne.

Mr. THOMAS RONTREE, Colliery Manager, 12, Northcote Street, South Shields.

Mr. PHILIP H. STANTON, Colliery Manager, Throckley Colliery, Newcastle-upon-Tyne.

Mr. C. H. STEAVENSON, Manager, Brotton Mines, Brotton, R.S.O., Yorkshire.

Mr. WILLIAM TATTLEY, Mine Manager, Taupiri Extended Coal Mining Co., Ltd., Huntly, Waikato, New Zealand.

Mr. GEORGE A. TREADWELL, Mining Engineer, Nevada City, California, U.S.A.

Mr. WALTER DE VARILA, Mining and Topographical Engineer, Room 9, 316, California Street, San Francisco, California, U.S.A.

Mr. THOMAS WALTON, Colliery Manager, Habergham Colliery, Burnley.

Mr. JOSEPH D. WEEKS, President, American Institute of Mining Engineers, Pittsburg, Pa., U.S.A.

Mr. JOHN WOOD, Mining Engineer, Coxhoe Hall, Co. Durham.

Mr. G. C. ZUMBULOGLON, Mining Engineer, No. 3, Astardji han, Grand Bazaar, Constantinople.

ASSOCIATE MEMBERS—

Mr. JOHN RIDLEY RITSON, Burnhope Colliery, Lanchester.

Mr. E. P. WOOD, Commissioner of Mines, Department of Mines, Georgetown, Demerara, British Guiana.

ASSOCIATES—

Mr. GEORGE BAKER, Mining Surveyor, Bedlington Colliery, Bedlington, R.S.O.

Mr. JOHN HINDMARCH, Colliery Overman, Isabella Pit, Newsham, Blyth.

Mr. THOMAS WATSON, Science Teacher, East Hedley Hope, Tow Law, R.S.O.

STUDENTS—

Mr. THOMAS ELLIOTT PARRINGTON, Mining Pupil, Holywell Hall, Durham.

Mr. ROBERT ROWELL SIMPSON, Mining Apprentice, 11, Haldane Terrace, Jesmond, Newcastle-upon-Tyne.

DISCUSSION UPON THE "REPORT OF THE PROCEEDINGS OF THE EXPLOSIVES COMMITTEE."*

The SECRETARY read the following correspondence with the Secretary of State for the Home Department, respecting the use of the plant erected by the Institute for testing explosives to be used in mines :—

NEVILLE HALL,
NEWCASTLE-UPON-TYNE,
July 12th, 1895.

Sir,—The President and Council of this Institute have considered the following question which Mr. John Wilson asked recently in the House of Commons and Mr. Asquith's reply as follows :—

"Mr. John Wilson (Durham) asked the Secretary of State for the Home Department whether he had decided to utilize the apparatus for testing westfalit erected at Messrs. Pearson and Knowles' collieries, near Wigan, for testing all other safety explosives used in mines ; and whether he was aware that efficient apparatus had been erected by the North of England Institute of Mining and Mechanical Engineers, at a cost of about £500, and which had been seen and approved by several members of the Royal Commission on Explosions from Coal-dust ; and if so, whether he would take steps to secure that any experiments with explosives now used in mines should be carried out by gentlemen not connected with the manufacture of explosives."

"Mr. Asquith said he had not decided to cause this apparatus to be utilized, but if there should be need of it he would be very willing to accept the loan of suitable apparatus from any quarter. He was aware of the apparatus belonging to the North of England Institute of Mining and Mechanical Engineers; in fact, some of the inspectors of mines had been assisting at their experiments. Until the passing of a bill dealing with the use of explosives in dangerous mines, it would be premature to initiate experiments with different sorts of explosives, but he was fully alive to the necessity of impartiality in any experiments that might be made, and, he might add, he hoped very shortly to introduce a bill."

* *Trans. Fed. Inst.*, vol. viii., pages 227 and 593, and vol. ix., pages 115, 206, and 274.

In view of the fact that the apparatus erected by this Institute has been seen and approved by several members of the Royal Commission on Explosions from Coal-dust, the President and Council have pleasure, on behalf of the members, in offering to the Secretary of State for the Home Department the use of the entire plant for testing explosives proposed to be used in mines.

The apparatus is now being used for this purpose, and can be seen at any time either by yourself or any representative you may send down for the purpose, and a series of experiments can be arranged for any day which you or he may appoint.

I enclose herewith two copies of the preliminary report of the Explosives Committee and two advance copies of a further report on a seventh explosive.

I have the honour to be, Sir,
Your obedient Servant,
M. WALTON BROWN,
Secretary.

The Secretary of State,
Home Office, Whitehall, London, S.W.

WHITEHALL,
22*nd July*, 1895.

Sir,—With reference to your letter of the 12th instant, I am directed by the Secretary of State to say that he will bear in mind the kind offer of the use of their explosives testing apparatus which the North of England Institute of Mining and Mechanical Engineers make, if at any time it be considered desirable to make experiments of the nature indicated in your letter.

I am at the same time to express the thanks of the Secretary of State for the copies of *Reports* on explosives forwarded by you.

I am, Sir, your obedient Servant,
KENELM E. DIGBY.

The Secretary of the North of England Institute
of Mining and Mechanical Engineers, Newcastle-upon-Tyne.

Mr. G. BENEKÉ (London) wrote that the material used in the experiments could not have been genuine westfalit, and the analyses made by Dr. Bedson and Mr. Saville Shaw,* bear out this view. Presuming that genuine westfalit had been employed, the experiments must be condemned as most unfair, because No. 8 detonators were used, containing exactly double the amount of fulminate of mercury of that in No. 6 detonators, which were employed in the experiments with bellite, securite, ammonite, roburite, carbonite, and ardeer powder. He also desired to point out that no analytical chemist or expert in explosives would use a No. 8 detonator to ignite such a small quantity as 1½ ounces of explosive, although he had no hesitation in recommending the use of No. 8 or No. 9 detonators with all nitrate-of-ammonium explosives provided that at least 6 ounces charges were employed.

He (Mr. Beneké) desired to add that he had as yet never supplied an ounce of westfalit to any colliery in the United Kingdom, and, conse-

* Report, page 71.

quently, the committee could not have procured the material from any English mine. Only two consignments of westfalit had been shipped to this country. One parcel of 1,780 lbs. was received in January, 1894, by Mr. D. Paisley, the whole of which, however, is held under an injunction by order of the Court. This material had to be returned to Germany, as it was faulty and unfinished, being the result of the first attempt to manufacture westfalit. The second parcel of 2,000 lbs. was shipped in August, 1894, to Messrs. Benley & Company. This consignment is of proper and excellent manufacture, and is held under his (Mr. Beneké's) entire control, and not an ounce of it has been supplied to anybody. He (Mr. Beneké) was willing to experiment with genuine westfalit, under the supervision of the Explosives Committee, at any time; and if his offer was not accepted, as soon as the English factory is completed, he was willing to furnish the committee with the names of collieries in Great Britain using westfalit, so that they may be able to procure samples for experimental purposes under their own conditions.

The results of numerous experiments made at Wigan by members of the Midland Institute of Mining, Civil, and Mechanical Engineers,* and at Neunkirchen, and latterly for the Austrian Government, give westfalit first place for safety and strength.

A most daring fraud has recently been perpetrated upon another explosive-manufacturer, who discovered that his cartridges had been tampered with and refilled with a spurious and bad imitation, for the express purpose of doing him a serious injury. It was, therefore, no criterion for the genuineness of westfalit used by the committee that the cartridges bore presumably the stamp of the manufacturer on the paper covers.

Dr. P. PHILLIPS BEDSON (Newcastle-upon-Tyne) wrote that in "An Investigation as to whether the Fumes produced by the use of Roburite and Tonite in Coal-mines are Injurious to Health," read before The Federated Institution of Mining Engineers, there was an analysis given of roburite, which, in the light of facts recently brought under his (Dr. Bedson's) notice, required explanation and correction. As stated in the paragraph headed "Composition and Analysis of Roburite,"† this explosive claims to be manufactured from chlorinated di-nitrobenzine and ammonium nitrate. For the purposes of the analysis of this explosive it appeared, therefore, sufficient to determine the proportions of ammonium nitrate and of the organic constituent, the latter by its insolubility in

* *Trans. Fed. Inst.*, vol ix., page 294. † *Trans. Fed. Inst.*, vol. ii., page 396.

water and solubility in ether is easily separated from the ammonium nitrate, and its amount determined. The amount of the ammonium nitrate was arrived at by a determination of the ammonia contained in the aqueous extract of the explosive. The organic constituent soluble in ether was returned in the analysis as chloro-dinitrobenzene, and its melting-point given. In the face of the description given of roburite this was deemed sufficient, and it was not considered necessary to ascertain whether the organic material contained chlorine, seeing that there was another explosive already consisting of di-nitrobenzene and ammonium nitrate. The examination, however, of recent makes of roburite prove that this attitude was not entirely justifiable, as he (Dr. Bedson) had found several samples examined lately to consist practically of mixtures of ammonium nitrate and of di-nitrobenzene.

He (Dr. Bedson) therefore wished to make a correction in the analysis of roburite given in his former communication, and to substitute for chloro-dinitrobenzene (soluble in ether) nitrated hydrocarbon (portion soluble in ether); the analysis would then read as follows:—

	No. 50.		No. 51.
Moisture	1·14	...	0·66
Ammonium nitrate	83·35	...	86·30
Nitrated hydrocarbon (soluble in ether) ...	11·67*	...	11·74†
Matter insoluble in ether and in water ...	3·14	...	1·09
Fixed residue	0·70	...	0·21
Totals	100·00		100·00

Mr. HAROLD BONSER (Leeds) wrote that without in any way desiring to make the discussion an opportunity for rival explosives-manufacturers to bolster up their own specialities, he wished to correct an impression which may have been created in the minds of some members by the remarks of Mr. Orsman as to the liability of explosives manufactured from nitro-glycerine to be easily detonated by dropping weights upon them. Admitting that liquid nitro-glycerine is highly susceptible to detonation, when manufactured into solid explosives it loses this dangerous attribute, thus—weights of 420 lbs. have been dropped upon a box containing 50 lbs. of dynamite from a height of 45 feet, smashing the box to pieces without detonating the explosive. In many tests made in quarries, boxes have been dropped from high places and smashed to pieces without the contents being detonated. After an explosion of gas in a lead-mine in Derbyshire, he (Mr. Bonser) had picked up pieces of cartridges of gelatine-dynamite, the locker containing it having been

* Melting-point between 78 degs. and 82 degs. Cent.

† Melting-point 85 degs. Cent.

destroyed and the cartridges broken into small pieces and scattered without the explosive being detonated. After an explosion caused by ignition of dust in a colliery in Yorkshire, the cabin at the pit-bottom, which had experienced the full force of the shock of the explosion, was found to contain the gelignite intact, although it had been knocked about by the blast. The writer has seen cartridges of gelignite remain undetonated after being dropped down a shaft 1,800 feet deep on to a rock-bottom.

Mr. Orsman stated that "Nobel detonators, which are used principally for explosives containing nitro-glycerine, contain from 25 to 30 per cent. of chlorate of potash mixed with the fulminate of mercury, whilst ordinary detonators contain only a trace."* The following analyses of the detonators now in the market had been made, viz.:—

	Nobel's West Quarter.	Tonite.	Ammonite.	Roburite.
Fulminate of mercury	80	56·8	80	82·20
Chlorate of potash	20	29·6	20	17·80
Gun-cotton	—	13·6	—	—

From these analyses it will be seen that there is more than a trace of chlorate of potash in all these detonators. With the mixtures contained in these detonators a certain amount of flash will be produced on ignition, and if fulminate of mercury were used alone, there would still be a flash.

He (Mr. Bonser) had charged many thousands of shots, and had therefore had considerable experience in stemming; he had never found anything better than a sun-dried unburnt brick, *i.e.*, clay, such as the Explosives Committee had used in their experiments. No length of stemming will prevent a blown-out shot if it be placed in the solid or fast, whilst from 9 to 12 inches will serve for ordinary shots. He (Mr. Bonser) was of opinion that all high explosives work better if the mouth of the shot-hole be filled up with clay after about 12 inches of stemming has been placed on the charge. This opinion might be illustrated by the fact that a very small portion of snow in the muzzle of a gun would cause the barrel to burst when fired.

Mr. W. C. BLACKETT pointed out that Mr. Bonser referred to stemming with "sun-dried unburnt brick, *i.e.*, clay, such as the Explosives Committee had used in their experiments." He understood that the stemming, however, used by the committee in their experiments was moist clay.

Mr. T. BELL (H.M. Inspector of Mines) referring to Mr. Beneké's offer to supply westfalit for experiment stated that if such were

* *Trans. Fed. Inst.*, vol. ix., page 216.

accepted by the committee it should be clearly understood that the samples would be submitted to analysis and to practical trials in the mine, so as to ensure that the explosive was of proper strength and composition. It was possible to make an explosive which might be flameless, but which would be of no use for practical work in the mine.

Mr. M. WALTON BROWN was surprised to learn the result of Dr. Bedson's further analyses of roburite. In 1890, he (Mr. Walton Brown), from information he had at that time received, described roburite as "a mixture of nitrate of ammonium, with not less than 5 per cent. and not more than 12 per cent. of chlorinated dinitro-benzol (containing not more than 4 per cent. of chlorine). The samples used appeared to be a mixture of 87 parts of nitrate of ammonium and 13 parts of chlorinated dinitro-benzol."*

In 1891, Mr. W. J. Orsman stated that roburite "differs essentially from other nitrate of ammonia mixtures with nitrated hydrocarbons in that the organic body is first chlorinated. The introduction of chlorine in this way causes more easy detonation of the finished explosive, and reduces the temperature of detonation, whilst the presence of chlorine compounds in the ultimate gaseous products, tends to still further reduce the effect of the escaping heated gases. The composition is as follows:—86 per cent. of nitrate of ammonium and 14 per cent. of dinitro-chloro-benzol."† Mr. Orsman also stated that "the chlorine present in the dinitro-chloro-benzene combines with the hydrogen to form hydrochloric acid, which exists as gas when the shot is fired, but, on the cooling of the gases, separates out with the condensed water-vapour."‡

In 1893, Mr. H. Bigg-Wither wrote that "roburite consists of an intimate mixture of chloro-dinitro-benzole and nitrate of ammonium. The chlorine is intended as an additional flame-quenching gas.§

More recently, Prof. Vivian B. Lewes stated that roburite "is a simple mixture of nitrate of ammonium with chlorinated meta-dinitro-benzol."‖

The authorized definition of roburite, as licensed in this country, is:—

* "Experiments with Explosives used in Mines." *Trans. Fed. Inst.*, vol. ii., page 51.

† "Notes on the Products and Temperature of Detonation of some High Explosives." *Ibid.*, vol. iii., page 95.

‡ *Ibid.*, vol. iv., page 126.

§ "Notes on Blasting in Coal-mines." *Ibid.*, vol. vi., page 541.

‖ "Mining Explosives." *Ibid.*, vol. ix., page 328.

Roburite No. 1, consisting of (*a*) nitrate of ammonium with or without an admixture of nitrate of sodium and neutral sulphate of ammonium, or either of them, provided that the amount of nitrate of sodium shall in no case exceed 50 per cent. of the total amount of nitrates present; and (*b*) thoroughly purified chlorinated dinitro-benzol with or without the addition of thoroughly purified chloro-nitro-naphthaline and chloro-nitro-benzol; provided (1) that such chlorinated dinitro-benzol shall not contain more than 4 parts by weight of chlorine to every 100 parts by weight of chlorinated dinitro-benzol; and (2) that the proportions of chloro-nitro-naphthalene and chloro-nitro-benzol shall not amount to more than 2 per cent. and 5 per cent. respectively of the finished explosive.*

Dr. A. Dupré, the chemical adviser of the Home Office, states that in 1894 he examined one sample of roburite, and it was "passed," or found to comply with the conditions defined in the license under which it is manufactured.†

A MEMBER mentioned that Mr. Winkhaus had stated that "roburite from the roburite factory at Witten-on-the-Ruhr" consisted "of dinitro-benzole, 17·8 per cent.; nitrate of ammonium, 79·2 per cent.; chloride of ammonium and sulphate of ammonium, 0·3 per cent.; water (damp arising from long storage of the sample), 2·7 per cent.‡ He asked whether the chlorine in the chloride of ammonium was equivalent in its action to that in chlorinated dinitro-benzol?

Mr. W. C. BLACKETT remarked that the manufacturers had always laid considerable stress upon the presence of chlorine in roburite.

Mr. BIGG-WITHER wrote that he was prepared to prove, if necessary, that roburite had always, without exception, been made with chlorinated dinitro-benzole, as defined in the license published annually by H.M. Inspectors of Explosives. He also stated that the detonators (marked R) supplied by the Roburite Explosives Company were guaranteed by the makers to contain 95 per cent. of fulminate of mercury.

The discussion was then adjourned.

* *Nineteenth Annual Report of H.M. Inspectors of Explosives*, 1894, page 89.

† *Ibid.*, page 19.

‡ "Experiments with Explosives." *Trans. Fed. Inst.*, vol. ix., page 259.

DISCUSSION ON MR. J. H. DARBY'S PAPER ON "THE SEMET-SOLVAY COKE-OVEN." *

Mr. JOHN H. DARBY (Wrexham) wrote, concerning the criticism that had been offered in reference to the Semet-Solvay coke-oven, that the first point seemed to be whether the Semet-Solvay oven is as suitable for coking rich coals containing 20 to 30 per cent. of volatile matter as other ovens. He is able to say that these coke-ovens are equally well, if not better, adapted, and are at the present time coking rich coals with excellent results. The thin walls between the coke-ovens and the flues had been found in practice to last a long time without repairs, wherever moderate care had been taken with the coke-ovens. In one works they had been at work for eight years and in another for five years without any stoppage for repairs. The quality of coke was not a secondary consideration with Messrs. Solvay in designing these ovens: the object they had in view was to design an apparatus which would give them the largest yield of by-products combined with the best metallurgical coke obtainable. In this they have been successful, as the consumption in the blast-furnace of 16·70 cwts. of Semet-Solvay coke per ton of pig-iron proved. The yield of by-products per ton of coal coked is:—

Tar	10½	gallons.
Ammonia-liquor, 8 degrees Twaddle ...	21·6	„
Light oil, specific gravity 0·890	1·8	„

In stating that a saving of 2 cwts. of coke per ton of pig-iron had been obtained, he meant to say that in working the same blast-furnace, with the same burden, and making the same class of pig-iron, a reduction of almost exactly 2 cwts. of coke per ton of pig-iron was found when using Semet-Solvay coke, as compared with the same furnace working on beehive coke made from the same class of coal.

Mr. A. L. Steavenson stated that the yield of coke he (Mr. Darby) had stated was impossible, and that there was not sufficient fixed carbon in the coal to give the yield of 80·5 per cent. The yields he (Mr. Darby) had given were from actual weights, and he had always found in working these coke-ovens that there was a larger yield of coke than the theoretical percentage of fixed carbon in the coal would admit. He explained this discrepancy by the fact that a quantity of carbon was deposited from the decomposition of the gases as they passed through the red-hot coke.

* *Trans. Fed. Inst.*, vol. ix., pages 54 and 282.

This fact proved to his mind that the Semet-Solvay coke-ovens must be perfectly tight, and that there was no loss by combustion of the carbon with air drawn in from the outside; he thought that this point showed that the working of these ovens was efficient and economical.

The coke from Semet-Solvay ovens watered outside was no doubt darker in colour than beehive coke, but the slight darkness of colour was no detriment to the economic value of the coke. If the coke was properly watered outside the ovens the percentage of water which it contained might be kept down regularly to 1 or 2 per cent.

Mr. W. Cochrane stated that 25 or 30 years ago he adopted a Belgian oven similar in type to the Semet-Solvay. He (Mr. Darby) believed that the ovens referred to were 4 feet wide inside or thereabouts, so that whatever may have been the source of heat and its mode of application it was an absolute impossibility that the heat could effectively coke the coal in the centre of this huge mass. Coke was a bad conductor of heat, and, therefore, to obtain a large production the ovens must be reduced in width. The Semet-Solvay coke-oven was generally made between 12 and 18 inches wide, and varied according to the class of coal to be treated. The weight of small coke and breeze was not more than 2 per cent., and from the statements which he had given it appeared that the coke was admirably suited for blast-furnace work.

The Semet-Solvay coke-ovens were drawn out at regular intervals during day and night. The height of the blast-furnaces in which the coke had been used varied from 48 to 80 feet.

"The much desired silvery appearance," spoken of by Mr. L. H. Armour, is of absolutely no value in the blast-furnace; this is proved by the fact that it is the universal practice on the Continent to use darkish-looking retort-coke in the blast-furnace, and it must be admitted that Belgium, Germany, and Austria are pushing British iron-makers hard in the question of cheap and efficient production of pig-iron. Mr. Armour described the way in which deposited carbon was formed in coke-ovens; this deposition of carbon takes place in the Semet-Solvay oven as in other ovens giving rise to the increased yield of coke.

If Semet-Solvay coke were taken red-hot immediately on its discharge from the oven and cooled without access of air it would have the same silvery appearance as beehive coke watered inside the oven; it is the action of the water on the coke which produces the darkish colour on the outside surface of the deposited carbon. The deposited carbon is there without doubt, as special means have to be used to prevent this carbon from furring up the ovens and ascension-pipes, and considerable quantities of it can be collected from this source alone.

It is the fact that Semet-Solvay ovens will pay for their own cost, including recovery-plant, in two to two and a half years. Mr. Blackett remarks that the Semet-Solvay oven has only made this profit on paper, but he (Mr. Darby) was assured that his statements were correct and founded on practical results.

Semet-Solvay ovens have been working for 8 years with the same lining, and they have not yet required renewals. The ovens, however, are designed so that, in the case of renewals being required, these could be easily effected. He (Mr. Darby) did not wish to state for one moment that Semet-Solvay ovens never wear out, because they do so after a fair life, and when this time arrives the arrangement he had spoken of affords ready means for changing the parts.

Mr. B. Dodd remarked that the cost of the plant and the speed and economy of working depended upon the power of the condensing-plant. This is so to some extent, but the condensing-plant must be sufficient for the maximum production of the ovens, and if the condensing part of the recovery-plant is properly designed there will be very few stoppages. For a given amount of coke per day, he denied that larger hoppers were required for the storage of coal, or that increased siding and waggon accommodation was wanted. The coke was produced in a smaller area, and a considerable saving was effected in the siding accommodation. No doubt the question of Sunday and holiday labour must be faced, as at the blast-furnaces; but the labour required was of a much easier and less exacting kind than discharging, for instance, the beehive coke-oven by hand. In the Semet-Solvay oven the coke was discharged by a ram. He presumed that Mr. Dodd meant that one Cleveland firm had used coke in its blast-furnaces, 77 per cent. of which was made in Simon-Carvés ovens, and the same price was paid for this as for beehive coke. It would seem from his remarks that 77 per cent. of the coke used in Cleveland was made in retort ovens: he regretted, for the sake of coke-producers, that this was not the case.

As he (Mr. Darby) had before stated, and judging from records of results, he was of opinion that there is no system of retort-oven which produces a coke capable of giving such economical returns in the blast-furnace as the Semet-Solvay coke-oven.

Mr. A. L. STEAVENSON said that since the last meeting he had seen some ovens drawn of a similar character to those described in the paper, and very excellent coke was produced. He thought that the makers of retort-ovens were too anxious to get the by-products, and had not

sufficiently allowed the coke to harden after the gases were driven off. The coke usually came out of the ovens with a soft black parting in the middle, which was valueless; however, on this occasion, the coke when drawn was really excellent.

Mr. W. C. BLACKETT said that Mr. Darby had misrepresented some of the remarks made in the previous discussion. With reference to his own remarks, he did not say that Mr. Darby's figures appeared on paper, but what he did say was that "he took the basis figures used for the Semet-Solvay ovens and applied them to a plant of coke-ovens, such as he would imagine would be placed in the category of "despised bee-hives," and he discovered that where the Semet-Solvay oven would give 70 per cent. of profit, the bee-hive oven would give 60 per cent."* In this statement he had not taken account of any value for heating the boilers which supplied steam at the colliery. Of course, such a statement was absolutely valueless in practice, and it was obvious that if a low price of coal was taken and the coke was put at the top price, a large margin of profit was shown which could not be realized.

DISCUSSION ON MR. J. D. KENDALL'S PAPER ON "MISS-FIRES."†

Mr. J. D. KENDALL (Whitehaven) wrote that he had been making further experiments with the view of still further reducing the number of accidents resulting from the use of explosives in mines. He had already shown that defective fuze was the most frequent cause of miss-fires, and he had since been endeavouring to remove those defects, or at any rate, the risks accompanying them. It was a common, if not a universal, opinion among miners, that many of the accidents following miss-fires were due to the fuze hanging fire. A careful consideration of this subject had led him (Mr. Kendall) to the conclusion that hanging fire could only be certainly prevented by employing fuzes from which threads of every kind were absent. He had therefore entirely discarded the ordinary guttapercha and thread-fuzes for one which could not by any possibility hang fire. This fuze, the "ferruled-tube fuze," is made of lead, is $\frac{1}{8}$ inch in diameter outside, and has a $\frac{1}{16}$ inch powder-train running through it. The ordinary detonators used with nitro-glycerine explosives being nearly $\frac{1}{4}$ inch in internal diameter, it is necessary in using ferruled-

* *Trans. Fed. Inst.*, vol. ix., page 282.

† *Ibid.*, vol. vii., page 605, and vol. ix., page 31.

tube fuze to employ a ferrule *B*, as shown in Fig. 1, to secure a proper fit between the fuze *C* and detonator *A*. A longer detonator of less diameter would not be so suitable, as the detonating material would then be less concentrated. In using this fuze, a ferrule is slipped on its end before it is placed in the detonator. The latter is then gently nipped on to the fuze

Fig. 1.

with a pair of detonator-pliers and is ready for use. It has been suggested that ferruled-tube fuze would not bear the rough usage generally given to fuze by miners, but he (Mr. Kendall) had had holes stemmed with it in the very roughest manner likely to be adopted in practice, without interfering in the least with its action. It cannot, however, be too strongly insisted on, as pointed out in his previous communication, that there is no necessity whatever for heavy stemming, and therefore no need for using fuze roughly. It has also been thought by persons who have not used ferruled-tube fuze that the lead of which it is made, on coming into contact with the fulminate of mercury in the detonator might possibly cause a premature explosion of the latter, but numerous experiments made with that end in view, have shown that there is not the least fear of such a result. He (Mr. Kendall) had sharpened the fuze to as fine a point as possible and scratched the detonating material with it, but had not been able to produce an explosion. In addition to the greatly increased safety which results from the prevention of hanging-fire by the use of the ferruled-tube fuze, there is a great saving of time, as it is unnecessary for the miner to wait more than a minute or two after a miss-fire, instead of about twenty minutes, the minimum time necessary for safety when ordinary thread-fuzes are in use. Another most important feature of ferruled-tube fuze is that it produces less than one-sixth of the smoke given off by thread and guttapercha-fuzes. This, of itself, is a great advantage, especially in mines or workings where the ventilation is weak; all miners who have used the fuze speak most highly of it, as it allows them to return to their work so very much sooner after firing. The ferruled-tube fuze is not more expensive than the best guttapercha-fuze, and is cheaper than leaden fuzes, which are made thick enough to fit ordinary detonators. Thin-tube fuzes having no means of fitting them to the detonators, cannot be used with anything like the facility or certainty that is possible with ferruled-tube fuze. In conclusion, he (Mr. Kendall) submitted that if holes be charged as previously recommended

with only a few inches of stemming, and if ferruled-tube fuze be used to explode the charges, accidents from miss-fires will become a thing of the past. Any of the ordinary leaden fuzes, if properly made would prove efficient, but for the reasons above-named ferruled-tube fuze is preferred.

DISCUSSION ON MR. R. RUSSELL'S PAPER ON "THE EXTENSION OF THE WEST CUMBERLAND COAL-FIELD," ETC.*

Mr. BURNS said that on reading this paper he felt a little disappointment, inasmuch as he thought Mr. Russell would have dealt more definitely with the northern extension of the Coal-measures especially. It seemed to him (Mr. Burns) that the extension of the Cumberland coal-field in the direction of the Solway towards Silloth and Carlisle was the greatest unsolved mining problem in the North of England, and it was desirable that an authority like Mr. Russell, who had studied the geology of Cumberland so minutely, should have given them something definite. It seemed to him that Mr. Russell was too pessimistic about the existence of this coal-field, and seemed to regard the connexion between the red beds on the north and the exposed Coal-measures as more of an unconformity than a fault. He thought there could be little doubt that there was a very large fault running north of the known Coal-measures, and that had been more particularly explored at Crosby, and he did not think that Mr. Russell explained all the effects in connexion with that exploration which he might have done.

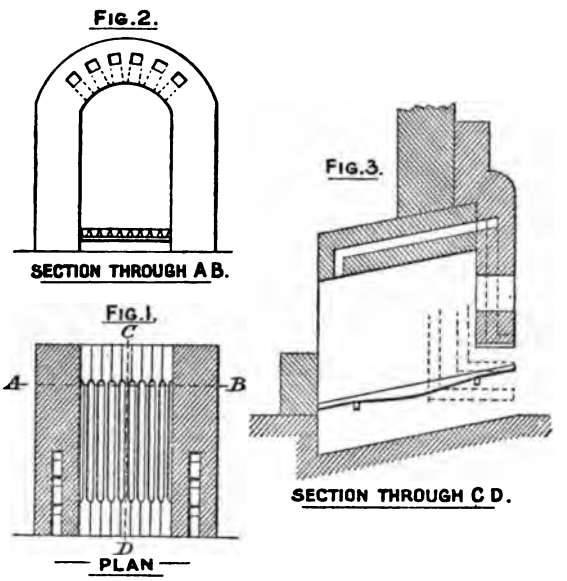
In treating of the southern part of the coal-field, Mr. Russell made it clear that the red beds were laid unconformably on the Carboniferous beds below. That being so, the disposition of the red beds gave no necessary clue to the disposition of the Carboniferous beds below. The results of the Crosby explorations tended to show that there was a series of faults, and that the existence of the red measures was no necessary evidence of the absence of the Coal-measures to the north. His (Mr. Burns') idea was that the evidence of a very large downthrow fault, or series of faults, from Maryport to Aspatria was very strong indeed, and the exploration of them, although not completely satisfactory, was not of the negative value which Mr. Russell attached to it.

He did not agree with the criticism of Mr. Kendall, in which he blamed Mr. Russell for "guessing" at the depth of the Coal-measures from Allonby to Carlisle, because Mr. Russell from his large experience ought to be able to estimate very nearly the depth of those beds—if they did exist.

* *Trans. Fed. Inst.*, vol. viii., page 276, and vol. ix., page 31.

DISCUSSION ON MR. R. W. MOORE'S PAPER ON "IMPROVEMENTS IN BRICK-KILNS."*

Mr. PHILIP KIRKUP (Durham) wrote that the annexed plans (Figs. 1, 2, and 3) showed the details of the Anderson hot-air furnaces used at the Cornsay brickworks. The air is admitted at two or three apertures at the side of the furnace, and conveyed by channels parallel to the furnace to the crown of the arch, and there admitted to the fire to complete the combustion of the fuel. The consumption of fuel by an



ordinary Newcastle brick-kiln, fed with cold air, was 22½ cwts. per thousand for 8,000 3 inches fire-bricks. By the adaptation of the Anderson hot-air fires to the same kiln, the same quantity of bricks was burnt equally well with 16¼ cwts. of coal per thousand. He believed that the application of these fires to round-shaped down-draught kilns would probably give better results.

Mr. R. W. MOORE (Whitehaven) wrote that the results obtained by the use of the Anderson hot-air furnaces at the Cornsay brick-works did not equal those obtained by the kilns in use at the Seaton fire-brick

* *Trans. Fed. Inst.*, vol. viii., page 26.

works, near Workington, which he (Mr. Moore) had described in his paper. The consumption of fuel at the Cornsay brick-works was 16¼ cwts. of coal per thousand fire-bricks burnt, whereas at Seaton the consumption was only 12 cwts. of the poorest quality of small and duff, which was absolutely unsaleable. Seaton kilns had lately been erected at the Portland colliery, near Kilmarnock, and at the Larbert brick-works, near Stirling, and had given great satisfaction. At the former place the average time occupied in burning kilns, containing from 13,000 to 15,000 fire-bricks, had been thirty-five hours, and the average cost for coal for firing (including the steaming of other kilns) was 1s. 9d. per thousand. The bricks in the Seaton kiln were burnt evenly throughout. Without knowing the actual circumstances at the Cornsay brick-works, he (Mr. Moore) was inclined to think that the application of increased heat at the top of the Cornsay kilns might unduly burn the uppermost bricks, while leaving the bottom ones soft. He also wished to point out that the Cornsay kiln, as described by Mr. Kirkup, made no provision for the utilization of the waste-heat for drying or steaming the contents of other kilns—the special feature of the Seaton kiln.

Mr. A. L. Steavenson read the following paper on "The Mode of obtaining a True North Line":—

THE MODE OF OBTAINING A TRUE NORTH LINE.

By A. L. STEAVENSON.

The subject of accurate plans, and how to make them, is one which has been before this Institute from a very early period of its existence.

In March, 1856—probably the first meeting at which the writer was present—the President, Mr. Nicholas Wood, introduced Mr. Beanlands to the members, saying that he "proposed to obtain the true meridian in the workings of a coal-mine, and so enable them to obtain accurate surveys with the theodolite." Mr. Beanlands, in reply, said that "he had first attempted to effect the desired object by observing the passage of stars across the zenith, ... but the method was attended in practice with much difficulty," and that he had therefore "devised a plan for effecting the same object by observations made with artificially illuminated marks, ... the direction of a line at the bottom of the shaft being fixed with reference to the true meridian." *

On a subsequent occasion Mr. Beanlands gave the Institute a very excellent paper on "Mining Surveys,†" in which he fully described his method of connecting the plan of the surface with that of the underground workings by means of the transit instrument—a system the writer believes to be the only reliable one for pits over, say, 200 feet in depth, or where there are shafts at a considerable distance apart, affording easy communication below.

In September, 1870, Mr. W. F. Howard communicated an excellent paper on "Practice in Underground Surveying,‡" etc., and he (whilst properly condemning the hedge surveyor of the old school, with his chain and cross-staff, who occupied but did not fill the place of the engineering surveyor demanded by the occasion, and the dialler of the old school) gave a very good description of his mode of using the fast needle and his system of book-keeping. Whilst giving the preference to making the survey between two shafts, to the system of Mr. Beanlands, he says "it is far preferable to deriving the base from observation by a transit instrument down a shaft," in which opinion the writer differs from him.

* *Trans. N. E. Inst.*, vol. iv., page 121. † *Ibid.*, vol. iv., page 267.
‡ *Ibid.*, vol. xx. page 19.

But, he says, "the most convenient basis of the system of bearings . . . . is undoubtedly—for underground surveying and its subsequent processes—a meridian line."

This paper was followed by one from Mr. Beanlands upon "Improvements in Underground Surveying,"* in which he gave his reasons for maintaining that a "surveyor ought to rely principally on the theodolite in all underground surveys of large extent," and he claimed for his system of connecting the plans of the surface and of the underground workings, that the bearing of an underground line can generally be determined within one minute of arc which corresponds with a deviation of about 1 inch in 300 feet.

Recently Prof. H. Stroud has communicated an interesting paper upon "Magnetic Declination and its Variations"† showing that the magnetic needle is not reliable :—

(1) At various seasons of the year.

(2) At different hours of the day.

(3) That the needle is influenced by sun-spots.

(4) By the action of magnetic earth-currents.

(5) Greatly influenced by magnetic storms; and he gives the instance of one on February 14th, 1892, when a change of declination of 1° 40′ was clearly shown at Kew within a period of 24 hours.

In the course of the discussion upon this paper Mr. H. Jepson said, speaking of the loose needle, that "the difficulty arose in properly applying a suitable correction . . . . by one method, the correction had been applied by . . . . an angle estimated to be sufficient for the declination of the needle for the lapse of time since the meridian had been drawn," and he further said, "when a new surveyor was appointed at a colliery he generally found considerable difficulties, ... not knowing what the last surveyor had used, by way of correction for declination."

Now it seems remarkable that during all these 40 years, when the question of accurate surveys, correct plans, different systems of surveying, and of connecting surface and underground plans, together with the value of the magnetic needle, has been before us, no one has at any time supplied the much-felt want of the means for obtaining the true north line.

It may, of course, be said, if we adopt the only perfect system of connexion between surface and underground, no true or magnetic north

* *Trans. N.E. Inst.*, vol. xx., page 85.

† *Trans. Fed. Inst.*, vol. vii., page 268.

line is needed; it is, however granted by Mr. Beanlands that some parts of the plan such as the details, subsequent to plotting the main lines, may be very well done by the magnetic needle. And of course, in all the other systems, whether based upon the fast or loose magnetic needle, a true base-line, to which to bring not merely the connecting-lines of the survey, but also the magnetic needle itself to be tested before and after each occasion on which it is in use is imperatively necessary. What do we find in practice? Probably there is not a single mining plan in the north of England on which there is not to be found a line which, however far from the fact, is given as the north line, sometimes the year to which it applied being added.

Now, the writer contends that there should be on the surface at each mine a meridian line, carefully and substantially marked out, not less than 600 feet in length.

To define a line of this kind is really a simple matter, and as few have been found by the writer to be aware of the method of doing it, it has seemed desirable to devote a short time to the demonstration of what it involves, viz., the possession of a theodolite or transit instrument, an Ordnance Survey map of the district, and a good watch carefully set by Greenwich time.

The meridian of any place is represented by a line drawn through it from the north to the south pole, and as the sun or stars cross this line they reach their greatest elevation, and are said to transit. The times of right ascension or transit are given for the principal stars and the sidereal time each day at noon in the *Nautical Almanac* and also in *Whitaker's Almanac* each year. Perhaps the shortest and best way to describe the *modus operandi* is to take a case, and suppose that the writer wishes to describe a meridian line at his own house.

Referring to the Ordnance Survey map, and with a parallel ruler drawing lines vertical and horizontal through the point in question, he finds that the latitude is 54° 43′ 49″ and the longitude 1° 36′ 41″ and as there are 360 degs. of longitude which the revolution of the earth performs in 24 hours, he finds that the allowance of time to be made for the position west of Greenwich is 6 minutes 26·7 seconds, that is to say local time at Holywell is so much behind Greenwich time.

Now, with respect to the altitude of a star, the elevation is given as "declination." Declination is measured vertically above or below the the equator, and corresponds to latitude on the earth's surface, and the height of the equator corresponds with the co-latitude of a place, that is to say, its height on the meridian is equal to our co-latitude, thus:—

	Degs.	Mins.	Secs.
Constant	90	0	0
Latitude of Holywell	54	43	49
Co-latitude or height of the equator on the meridian at Holywell	35	16	11

Now we are in a position to find our star to-night, say, August 3rd. On referring to *Whitaker's Almanac*, page 42, we find that on August 3rd the sidereal time at mean noon is 8 hours 47 minutes 16 seconds, and as we want to do our work as soon after dark as possible, we will take a star passing about 10 o'clock. On page 80, we find that the star Vega (α Lyræ) has a right ascension of

	Degs.	Mins.	Secs.
	18	33	23
From this deduct sidereal time of August 3rd ...	8	47	16
Difference	9	46	7
From this we must deduct the difference which has occurred between our mean time and sidereal time since noon, at the rate of 9·85 or 10 seconds per hour	0	1	37
Due at Greenwich	9	44	30
And add to this the time-allowance required by our longitude	0	6	27
Then Vega passes our meridian on August 3rd at	9	50	57

But we must next find the elevation, thus:—

To our co-latitude	35	16	11
We add declination of Vega	38	41	10
And we get the altitude	73	57	21

If, however, this is too high to be seen in the theodolite, we might take the star μ Sagittarii, the declination being $-21^\circ\ 5'\ 10''$: in this case it must be deducted from the co-latitude, being a minus or south declination.

Having, then, a good watch, carefully set by Greenwich time—say, by the gun at Shields—we proceed about 9·30 p.m. to put the theodolite in position to observe the star, which the instrument very soon indicates for a few minutes before the watch reaches the time of 9 hours 50 minutes 57 seconds p.m.; and at the exact moment the instrument is pointing true south. Before making permanent marks it will be well to repeat the observation, both on other stars and on other nights, and take the average or mean of them.

In conclusion, it seems only desirable to point out that having once got this base-line or meridian, how interesting and valuable a means it affords for afterwards checking and regulating clocks and watches; to

set a transit instrument for a given star on a fine clear night, watch it appear in the field of observation, exhibiting as it does the incomprehensible regularity of the heavenly bodies, is a delightful recreation, which has served to amuse and occupy the writer for many years, and induces him to encourage his hearers and readers to try it.

Mr. STEAVENSON said that a slight correction was required for latitude to find the elevation, but it was so very small that it was not sufficient to carry the star outside the range of the instrument, and it was an easy matter to raise or lower it to the position required.

Mr. A. BEANLANDS remarked that the method proposed by Mr. Steavenson, though theoretically correct, was subject to the disadvantage that it required the time to be fixed with great precision. If the meridian line was to be determined from the transit of a star in the southern quarter of the heavens, or near the celestial equator, it should be borne in mind that such a star would be moving from east to west at the rate of 1° in 4 minutes, or 15′ in one minute of time, and accordingly, in order to determine the direction of the meridian within 1′ of arc, the time of transit must be ascertained correctly within about 4 seconds. He did not think that the true time could generally be fixed with this degree of accuracy in mining districts.

In the observations which he (Mr. Beanlands) had made to determine the meridian line he had preferred to avail himself of the Pole Star. This was always visible on a clear night, and owing to its slow motion an error of 1 minute in the time of observation would only affect the result to the extent of 35″, a little more than half a minute of arc.

There were several different methods which might be adopted in observing the Pole Star, using for this purpose the transit theodolite. Some of these methods he proposed briefly to describe :—

(1) The Pole Star might be observed on the meridian either at its upper or lower transit, the time being determined in the manner explained by Mr. Steavenson. He (Mr. Beanlands) thought it would be more convenient however to obtain the time of transit from the data furnished by the *Nautical Almanac*. If they referred to page III. in each month of that almanac they would find a column giving, for each day, the "Mean Time of transit of the First Point of Aries." The time of transit of the Pole Star would be found by adding to this the right ascension of the star as given on page 290. The lower transit would take place about 12 hours, or more correctly 11 hours 58 minutes after the upper transit.

(2) A meridian line might be determined by observing the Pole Star, in conjunction with another star having the same, or nearly the same, right ascension, or differing from it by 12 hours in right ascension. This method was described by Mr. Bennett Brough in his treatise on *Mine Surveying*.* Perhaps the most convenient star for the purpose was ζ (zeta) in the constellation Ursa Major—in other words, the middle star in the tail of the Great Bear. The time of transit must first be ascertained approximately ; and the theodolite being previously adjusted, the telescope must be pointed to the Pole Star, which must be bisected with the cross-wires. The instrument being then clamped in azimuth, the telescope must be lowered nearly to the horizon, when the star ζ (Ursa Major) would be seen at an altitude of about 5 degs. Without altering the horizontal position of the instrument, the star must then be watched until it appeared in the centre of the field of view. The telescope should then be raised and directed to the Pole Star, which should be again bisected, if necessary, by means of the tangent-screw. In this way we could obtain the direction of the Pole Star when the other star ζ (Ursa Major) was in the same vertical plane. This method would give the meridian line with considerable precision. This observation, however, could only be made in the autumn and winter, when the Pole Star would be visible at its upper transit during the hours of darkness.

There were two other stars, however, which might be conveniently observed in conjunction with the Pole Star at its lower transit. These were δ (delta) Cassiopeia in the northern hemisphere, and Spica or α (alpha) in the southern constellation Virgo. These stars would both be seen on the meridian, almost precisely at the same time as the Pole Star ; and by directing the transit-instrument so as to observe all the three stars in the same vertical plane, a very good determination of the meridian line might be obtained.

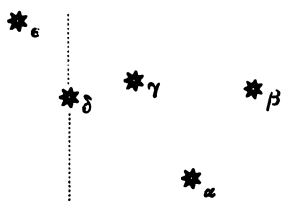


Fig. 1.

The constellation Cassiopeia could be easily recognized, as it was always visible in the northern hemisphere, being about the same distance from the Pole Star as Ursa Major in the opposite direction. The principal stars were five in number, arranged in a zigzag form (Fig. 1), and the star in question was the fourth in order, counting from east to west, when the constellation was below the pole.

* Page 48.

The star Spica would be at once recognized towards the south at an elevation of about 25°. There was no other very bright fixed star near it, but occasionally one of the brighter planets, Mars, Jupiter, or Saturn, would appear in this quarter of the heavens, and might possibly be observed by mistake. These stars, Spica and δ Cassiopeia, might be conveniently observed, in conjunction with the Pole Star, during the earlier months of the year, from about January 15th to May 10th.

(3) Another method was to observe the Pole Star six hours before or after the upper transit, when at its greatest distance east or west of the meridian. This observation might be made with considerable precision, as the star would then be apparently moving in a vertical direction. During the winter months it would be most convenient to observe the star six hours after the upper transit, at its farthest distance to the west. The instrument should be fixed and adjusted somewhat before the time specified, and pointed to the star which would then appear, with an inverting telescope, to be moving slowly upwards, and diverging slightly to the right. The star should then be followed by means of the tangent-screw, until it had reached its farthest point westward, and apparently to the right. If the telescope was now lowered to the horizontal position it would point in a direction inclined at an angle of 2° 10′ west of the true meridian, and accordingly it was simply necessary to move the instrument in azimuth towards the east, through this small angle, as shown by the verniers. The correction, 2° 10′, was calculated for the present year, and for the latitude 54° 45′. For places somewhat north of Newcastle it might be stated as 2° 11′. Owing to the slow progressive increase in the star's declination, this angle would be slightly reduced in future years, the change being at the rate of about 1′ in two years. It was scarcely necessary to remark that if the star were observed in this way six hours before its upper transit, as it might be during the summer months, it would then be at its greatest distance east of the meridian, and the correction of 2° 10′ would have to be made towards the west.

(4) There was yet another method which might be adopted in the months of December and January. At this time, the star might be observed twice during the same night, with an interval of twelve hours. The first observation would be made early in the evening when the Pole Star would be near its upper transit. A mark should then be fixed at a convenient distance in the direction given by the star. The observation should then be repeated on the following morning after an interval of 11 hours 58 minutes, when the star would be near its lower

transit, the theodolite being fixed on the same centre, and a distant mark put down as before. It was clear that whatever might be the deviation of the star from the meridian at the evening observation, there would be the same deviation, in the opposite direction, at the morning observation, and accordingly if we took the middle point between the two distant marks, this point, as seen from the instrument, would give the direction of the meridian line. This method, though not theoretically exact, would be sufficiently near for all practical purposes.

He (Mr. Beanlands) considered that each of the foregoing methods was suitable for the purpose required, and might be recommended for general adoption. They were all sufficiently accurate, and, with one exception, they required no special determination of the time. Moreover, they might be employed, one or other of them, almost at any period of the year.

Mr. J. A. RAMSAY said he would like to ask if the meridian line was really necessary for keeping a colliery plan. He did not exactly see how they could do without a meridian line, but for real accuracy he believed they would have only the theodolite to depend upon. Mr. Beanlands held the view that the greatest accuracy could be had by taking a sight down the shaft. By looking down a shaft they could not have a base-line longer than the diameter of the pit, but if there were several pits, a very much longer base-line could be got from the centres of two pits.

Mr. BEANLANDS observed that in using the theodolite it was important to obtain a proper connexion between the surface and underground surveys. This might be done by means of two shafts, as suggested by Mr. Ramsay; but the value of this method depended very much on the position of the two shafts. Even in favourable cases it would require a survey of great accuracy to give a result which would compare with that obtained by the transit instrument. He (Mr. Beanlands) had determined the bearing by the transit instrument in more than fifty collieries, and in some cases he could prove that the error, if any, was much less than 1′ of arc. He had occasionally, though rarely, made use of the datum afforded by two shafts. If, however, it was necessary to make the survey between the shafts simply to obtain the necessary connexion, the method would usually be much more laborious than using the transit instrument, particularly if the underground survey was very circuitous, and the result would be inferior in point of accuracy.

Mr. D. BURNS asked if it had ever been suggested to use an underground dial made on the principle of Lord Kelvins mariner's compass, with short needles designed to minimise the influence of magnetic surroundings. He agreed with Mr. Ramsay that if two permanent surface-objects were accurately set down on a colliery-plan and the underground workings accurately plotted with reference thereto, these permanent marks would serve the same purpose as a true meridian-line, and give permanent value to the survey.

Mr. J. A. RAMSAY, after hearing Mr. Beanlands' observations, said that he did not think there was any difference between them. At the last meeting he understood Mr. Beanlands to say that he would rely absolutely on the sight of the transit-instrument down the shaft, but now Mr. Beanlands said that failing another adjacent shaft it was certainly the best way to make an accurate survey. He (Mr. Ramsay) had not done such accurate work with a magnetic compass as with the theodolite; he was, however, of opinion that the theodolite properly adjusted was an instrument to be thoroughly relied upon for accuracy.

Mr. A. L. STEAVENSON said that with regard to Mr. Beanlands' preference for the north star, that star was a difficult object to reach, owing to its altitude. One great object of making these observations was to obtain the variation of the compass, and it was not necessary to be accurate to a minute part of a second; therefore to do as he had suggested and to repeat the observations a few times would render it practically accurate.

Mr. T. ELWEN read the following paper on "The Resistances of Air-currents in Mines":—

THE RESISTANCES OF AIR-CURRENTS IN MINES.

By T. L. ELWEN.

The writer had been requested to repeat the experiments recorded in his former paper on "The Effect of an Obstruction in the Air-way of a Mine,"* and with the view of having the results confirmed by the use of the König water-gauge,† he has carefully made additional experiments, the results being recorded below.

The construction and arrangement of the obstructions were identical in every particular with those used in the previous experiments, with the addition of the König water-gauge placed side by side with the ordinary water-gauge, the difference of pressure being read from each. (Figs. 1 and 2.)

The volume of air was less than in the preceding experiments, and the effect of this is shown in each reading, yet the principle is the same throughout the whole operation, which confirms the statements made by the writer in his previous paper.

Experiment No. 1.

The obstruction and the tail-brattice *D* and *E* at each end having been erected, the following observations were made:—

Volume of air per minute	18,720 cubic feet.
Velocity of air-current per minute at water-gauge	780 feet.
Velocity of air-current per minute at pipe-end ...	726 „
Water-gauge, ordinary	0·225 inch.
„ „ König	2·283 inches.

Experiment No. 2.

In this experiment advantage was taken of adjoining ventilating-doors to divert part of the air-current. The object being to ascertain the effect of a reduction of volume under conditions similar to those of experiment No. 1. The following results were observed:—

Volume of air per minute	11,232 cubic feet.
Velocity of air-current per minute at water-gauge	360 feet.
Velocity of air-current per minute at pipe-end ...	420 „
Water-gauge, ordinary	0·075 inch.
„ „ König	0·7865 „

* *Trans. Fed. Inst.*, vol. ix., page 36. † *Ibid.*, vol. iii., page 452.

With similar ventilating arrangements, and with the whole of the brattice and obstruction removed, the quantity of air per minute was 12,462 cubic feet.

Experiment No. 3.

The ventilation in this case was in its normal course, or under conditions similar to those prevailing in experiment No. 1. The out-bye end of the brattice *D* was taken down, the obstruction *C* and brattice *E* remaining in position. The following are the results :—

Volume of air per minute... ...	18,278 cubic feet.
Velocity of air-current per minute at water-gauge	832 feet.
Velocity of air-current per minute at pipe-end	692 ,,
Water-gauge, ordinary	0·235 inch.
,, ,, König	2·204 inches.

Experiment No. 4.

The in-bye end of the brattice *E* was taken down, leaving the obstruction *C* only in position. The results were as follows :—

Volume of air per minute... ...	17,355 cubic feet.
Velocity of air-current per minute at water-gauge	662 feet.
Velocity of air-current per minute at pipe-end	512 ,,
Water-gauge, ordinary	0·350 inch.
,, ,, König	3·464 inches.

Experiment No. 5.

To ascertain what difference, if any, existed in having the velocity of the current gradually brought

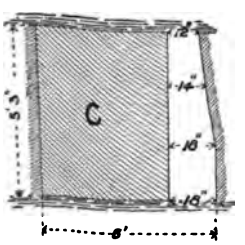


Fig 2—Section of Obstruction *C*.
Scale, 6 feet to 1 inch.

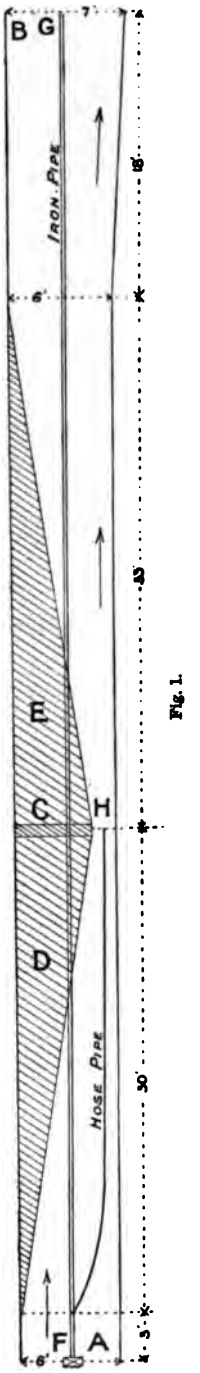


Fig. 1.

Fig. 1—Plan.
Scale, 12 feet to 1 inch.

References.

→ Direction of air-current.
C.—Obstruction.
D.—Outbye brattice.
E.—Inbye brattice.
F.—Water-gauge.
FG.—Iron pipe.
FH.—Hose pipe.

up to, and the swirling and eddying as it leaves the obstruction, the out-bye end of the brattice *D* was re-erected, and the obstruction *C* left in position. The results were as follows :—

Volume of air per minute	17,610 cubic feet.
Velocity of air-current per minute at water-gauge	724 feet.
Velocity of air-current per minute at pipe-end ...	692 „
Water-gauge, ordinary	0·275 inch.
„ „ König	2·680 inches.

Experiment No. 6.

As a correction in working out the pressures it was necessary to ascertain the amount of pressure lost on the rubbing surface. For this purpose the whole of the obstruction *C* and the brattices *D* and *E* were removed. The results were as follows :—

Volume of air per minute	20,943 cubic feet.
Velocity of air-current per minute at water-gauge	800 feet.
Velocity of air-current per minute at pipe-end ...	780 „
Water-gauge, ordinary	not ascertainable.
„ „ König	0·1575 inch.

In this experiment it was considered unnecessary to extend the length of the airway in order to obtain a reading of the ordinary water-gauge, as was done in the experiments recorded in the previous paper, for the König water-gauge gave the reading quite easily, thus showing the efficiency of this instrument for detecting small differences of ventilating pressure. The value of the coefficient of friction calculated from this experiment is practically the same as that previously obtained by the writer of this paper, viz., 0·0042 pound per square foot.*

The coefficient of the *vena contracta* in experiment No. 4 is 0·75.

In Table I., column 6, will be found recorded the total amount of resistance met with by the air-current in passing the obstruction from *A* to *B*, under the conditions therein stated. Column 7 shows the loss of pressure due to the air-current rubbing against the sides, top, and bottom of the air-way from *A* to *B*, calculated by using the coefficient of friction (0·004 lbs.), specially obtained for this length of air-way, and based on the assumption that the air-current travels in a straight line, which however is not so, and also disregarding the losses and gains of pressure owing to the continual alteration of velocity of the air in moving from *A* towards *B*. By subtracting column 7 from column 6, the results shown in column 8 are obtained, expressing the loss of pressure over and above that contained in column 7. The proportion that the results shown in column 7 bear to that of column 6 is shown in column 9.

* *Trans. N.E. Inst.*, vol. xxxviii., page 315 ; and *Trans. Fed. Inst.*, vol. ix., page 39.

TABLE I.—SUMMARY OF RESULTS OF EXPERIMENTS.

No. of Experiment.	Conditions of Experiment.	Volume of Air per Minute.	Pipe Water-gauge per Square Foot.	Velocity of Air-current at Water-gauge per Minute.	Velocity of Air-current at Pipe End per Minute.	Corrected Water-gauge for Difference of Velocity, per Square Foot.	Current Resistance per Square Foot.	Corrected Water-gauge, the Current Resistance being Deducted, per Sq. Ft.	Proportion of Current Resistance to Total Resistance.
		Cub. Ft.	Lbs.	Feet.	Feet.	Lbs.	Lbs.	Lbs.	
1	Obstruction *C* and brattices *D* and *E*	18,720	1·187	780	726	1·214	0·520	0·694	0·43
2	Obstruction *C* and brattices *D* and *E*	*11,232	0·409	360	420	0·424	0·186	0·238	0·44
3	Obstruction *C* and brattice *E* ...	18,278	1·146	832	692	1·216	0·268	0·948	0·22
4	Obstruction *C*	17,355	1·801	662	512	1·859	0·061	1·798	0·03
5	Obstruction *C* and brattice *D* ...	17,610	1·393	724	692	1·409	0·315	1·094	0·22
6	No obstructions ...	20,943	0·082	800	780	0·092	0·004	—	—
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

* With all obstructions removed the volume of air was 12,462 cubic feet per minute.

TABLE II.

No. of Experiment.	Conditions of Experiment.	Decrease of Air.	Increase of Pressure.	Reduction of Volume of Air, the Open Air way being taken as a Basis.
		Per Cent.	Per Cent.	Per Cent.
1	Obstruction *C* and brattices *D* and *E* ...	Basis.		10
2	Do. do. ...	—	—	10
3	Obstruction *C* and brattice *E*	2	36	12
4	Obstruction *C*	7	159	17
5	Obstruction *C* and brattice *D*	6	58	16

The difference in this air-way, between having an obstruction *C* with its attendant brattices *D* and *E* and no obstruction at all, will be seen by comparing Nos. 1 and 6 experiments. Even in this, the most favourable comparison, there is a great loss of pressure, and a reduction in the quantity of air, due to the conditions existing in No. 1 experiment. A certain amount of this loss is accounted for in column 7, and the remainder is due (so far as the writer can see) to the continual changes of direction of the air-current, and also to the varying velocity of the air, increasing as it proceeds from *A* towards the obstruction *C*, which involves an expenditure of power in creating the increased velocity at every step in its progression.

The König water-gauge used in these experiments gives readings ten times the amount of the ordinary water-gauge.

The following paper on "A Deposit found at Benwell Colliery, Benwell, Northumberland," by Messrs. J. C. Murton and Saville Shaw, was taken as read:—

A DEPOSIT FOUND AT DELAVAL COLLIERY, BENWELL, NORTHUMBERLAND.

By CHAS. J. MURTON and SAVILLE SHAW.

The low main coal-seam at Delaval colliery in which this deposit is found has been worked very extensively at this and neighbouring pits in olden times; but thanks to the difficulties of various kinds with which the "old-man" had to contend, such as creep, water, and probably gas, large tracts of the seam were formerly abandoned or purposely left as natural barriers either against the approach of creep or against water, and in these areas modern workings have been carried on for many years. The seam is a combination of the low main coal-seam and the five-quarter coal-seam lying immediately above it.

It may be noted that in this locality the value and nature of the workable seams are found to be altering. Northward and eastward the preponderance in number and thickness of the coal-seams is above the low main coal-seam, the quality being that which has supplied the steam-coal trade of the North of England for many years; but the strata below the low main coal-seam are comparatively poor in coal.

Here, however, between the high main coal-seam (which lies only a few feet below the surface at Benwell) and the low main coal-seam, there are no workable coal-seams, the well-known stone, metal, yard, bensham, and other seams, being rarely represented by more than a foot of coal. The beaumont and brockwell coal-seams (lying below the low main seam) are each about 3 feet thick.

But westward, following the rise of the strata, and compensating to a great extent for this barren space between the high main and low main coal-seams, the seams between the low main and brockwell seams increase in number and thickness, and become good coking coal, as at Throckley, Stella, and Mickley collieries.

In the course of exploring the "old-men's" workings, in the low main coal-seam, many relics of primitive character have been found. The high main coal-seam would be the first worked, possibly even by the Romans, as evidenced by cinders found at various "stations" on the Wall extending from the Tyne to the Solway, but only to a very limited

distance from the outcrop. The relics found in the low main coal-seam comprise oaken shovels (cut from the solid), wooden sledges, primitive chain-pumps, consisting of thick wooden pipes, iron chains with leather discs attached, etc., all pointing to workings made many hundreds of years ago.

It is recorded that in 1238 coal was worked in the high grounds of Benwell near Newcastle; that in 1673 the high main coal-seam in Benwell and Fenham estates was on fire, and that for 30 years previously the main coal-seam on the Town Moor of Newcastle-upon-Tyne had been burning. For short distances from the outcrops the other thin seams, such as the metal coal-seam, have been worked in olden times, and as the low main seam crops out in Scotswood Dene it would be entered by adit levels at very early dates.

In 1725, a pumping-engine was placed at Elswick quay, to drain the low main seam from the lowest point at the River Tyne to the rise. Much coal must have been worked, as there were then 300 or 400 pitmen living in Benwell village.

The section of the low main coal-seam in this locality varies slightly, but an average section of the entire seam is as follows :—

	Ft.	Ins.
Blue metal roof.		
Five-Quarter Coal-seam—		
Steam-coal	1	4
Fire-clay	2	2
Low Main Coal-seam—		
Coal	0	10
Black shale	1	0
Household coal...	3	6
Fire-clay	10	0

The bottom or house coal was naturally the first to be attacked, and there is generally plain evidence of the methods of working. Places were driven about 9 feet wide, and square pillars were left of the same width and breadth. No timber appears to have been used, as no signs of props have been seen. Occasionally larger pillars were left. The underclay has then risen until it pressed against the roof. Another set of operations then followed by which the remaining coal was worked, depending upon the "metal-rigs" as supports for the roof, which consisted of the bands, 10 inches coal, etc. All these workings have been driven in an irregular manner. In certain areas, where fortune favoured the workers, not a vestige of bottom coal is found over hundreds of square feet, its place being entirely filled by the bottom-clay and crushed bands. In the larger barriers, left as protection against "creep"

and water, a later set of workers have considerately left pillars of 15 or 20 feet in width and 60 feet in length, but only of dire necessity have they left a solid barrier untouched. In more recent times, the top coal has been partly worked, but it has occasionally been utilized by the "old-men," who drove air-courses or waterways in it. It is in the tracts in which the bottom coal has been entirely removed, and especially where the top coal has also been worked, that the deposit (the subject of this paper) is chiefly found. The seam lying to the rise of these adit-levels, is about 200 feet below the surface, and the bottom-clay has been subjected to two or three upheavals owing to the repeated operations of miners, thus being squeezed and ground in every direction. The seam here lies very flat, with a rise of only $\frac{1}{2}$ to 1 in 36. At various points in these workings, water rains from the roof, and the whole seam has lain water-logged for many years, until tapped by the recent workings. The deposit seems to have been formed in still water, and after the bottom had ceased to rise, as it is usually found lying level, though sometimes it is tilted and crumpled.

The usual thickness of the deposit is about 10 inches, and it has the appearance shown in Fig. 1.

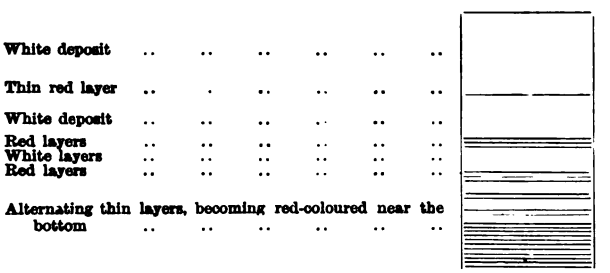


Fig. 1.

The uppermost part, 3 or 4 inches thick, is always nearly pure white, below that is a thin red layer, then white with a few red markings like marble ; then descending, the red-colour begins to predominate, until the bottom is generally formed of a red-coloured deposit.

The freshly-gathered uppermost deposit is a white earthy mass of the consistency of soft cheese, almost opaque, but possessing a slight though distinct opalescence. Exposed to the air it soon dries, shrinking considerably and forming a white, opaque, very friable mass, breaking with a conchoidal fracture. The dried substance adheres strongly to the tongue.

The specific gravity was found to be 1·7. Before the blow-pipe, it is quite infusible and imparts a slight calcium colouration to the non-luminous flame. Heated to dull redness, it loses the whole of its water

and at a slightly higher temperature white fumes of sulphuric anhydrid[illegible] are evolved. In a borax bead it dissolves completely, and with micro[illegible] cosmic salt leaves a slight, almost transparent, residue of silica. Moistene[illegible] with cobalt chloride and heated, it leaves a pure blue infusible residue[illegible] It is readily soluble in warm dilute hydrochloric acid, and the solution[illegible] gelatinizes on slight evaporation. The following figures show its composition :—

	Mean of two Analyses of the Air-dried Sample. Per Cent.		Composition calculated from Formula given below. Per Cent.
Alumina (Al_2O_3)	37·93	...	37·94
Silica (SiO_2)	12·12	...	11·80
Lime (CaO)	1·90	...	2·45
Sulphuric anhydride (SO_3)	5·30	...	5·25
Water	42·44	...	42·54
Totals	99·69	...	99·98

A trace of carbon dioxide was present, but not in sufficient quantity to allow of its estimation. After long exposure to the air, the effervescence caused by the addition of an acid is quite distinct, indicating that carbon di-oxide is absorded from the air as the substance hardens.

It is a matter of considerable difficulty to say exactly how the constituents of a substance of this character are combined. Prolonged digestion, with distilled water, failed to extract any trace of sulphate, though the whole of the lime disappeared and a little of the silica. This points to the lime being present as a hydrated calcium silicate decomposable by water and not as sulphate, and to the sulphuric acid being combined with part of the alumina as an insoluble basic sulphate. Microscopic examination confirms this view. Under a power of 500 diameters no trace of crystalline structure is discernible, as would be the case if calcium sulphate were present. The substance consists of a mass of minute irregular translucent particles about $\frac{1}{40000}$ inch in diameter, detached particles when suspended in water showing Brownian movement.

Were it not for the presence of the considerable percentage of sulphate, the analysis of the mineral would agree fairly well with those of some samples of collyrite or the mineral scarbröite, which it seems to resemble physically in some respects. The silica is entirely combined, as a hot solution of sodium carbonate failed to extract any.

Taking the sulphuric acid as being wholly combined with alumina, it would probably be present as insoluble basic sulphate, $Al_2(SO_4)_3 \cdot 2Al_2O_3 \cdot 9H_2O$ (the mineral aluminite) and the remainder of the alumina may

be considered as combined with part of the silica as the mineral collyrite ($2Al_2O_3 \cdot SiO_2 \cdot 9H_2O$), the rest of the silica being in combination with the lime as hydrated silicate.

The following rather complicated formula would then represent the constitution of the mineral :—

$$[Al_2(SO_4)_3 \cdot 2Al_2O_3 \cdot 9H_2O] \cdot 7 \; [2Al_2O_3 \cdot SiO_2 \cdot 9H_2O] \cdot 2 \; [CaO \cdot SiO_2 \cdot 18H_2O]$$

Aluminite. Collyrite.

Its mode of formation can only be a matter of conjecture. It seems probable that water containing free sulphuric acid, arising from the oxidation of pyrites in the coal, has by long contact with the underclay dissolved a part of it, forming aluminium sulphate and disintegrating the silica. Subsequent decomposition would then give rise to the formation of basic sulphate and the production of finely divided alumina, which, combining with the silica, would form the collyrite portion of the mineral.

The red layers in the deposit seem to consist of hydrated ferric oxide, though the sample analysed was not sufficiently free from adhering portions of the white substance for us to say with certainty that no basic ferric sulphate was present. Under the microscope it presents a peculiar appearance, consisting of masses of exceedingly minute interlacing fibres or crystalline needles. They are yellowish-brown in colour, and almost transparent.

A deposit, which physically is identical with the one now described, has been found by Mr. Norman Nisbet in old workings at Tanfield Lea colliery, Durham, and is at present being examined chemically.

It seems, indeed, probable that these deposits may be of fairly common occurrence, but owing to their being commercially valueless, they naturally attract little attention.

The following paper on "The Quicksilver Mines and Reduction-works at Huitzuco, Guerrero, Mexico," by Mr. Edward Halse, was taken as read :—

THE QUICKSILVER MINES AND REDUCTION-WORKS AT HUITZUCO, GUERRERO, MEXICO.

By EDWARD HALSE.

Situation and Topography.

Huitzuco is a small village close to the northern boundary of the State of Guerrero, 75 miles as the crow flies almost due south of Mexico City, and 42 miles south a little east of Cuernavaca, the capital of the small state of Morelos.

It is reached by the Interoceanic Railroad, the nearest station being Jojutla, in Morelos. From the latter small town to the mines is a ten-hours' ride on horseback, at first over moderately hilly and wooded ground, twice crossing a branch of the Rio de Las Balsas, then along somewhat steep and rocky canyons clothed principally with mesquite, cacti, and small palm-trees, until one at length emerges from a deep and beautiful lime-stone-gorge and enters on the green Huitzuco valley.

The mines are situated in the district of Hidalgo on small rolling hills one mile to the south of Huitzuco, which is built just above a gully connecting with the valley or grassy plains above mentioned. North of the village the background is formed by a high range of hills with a general east-and-west trend.

The altitude above sea-level is about 3,000 feet. The climate is warm, but not unhealthy—the insalubrious *tierra caliente* being more to the south.

Geological Features.

The rock at and in the immediate neighbourhood of the mines consists of limestone, with patches of gypsum, and is of Cretaceous age. The range of hills to the north of Huitzuco consists mainly of eruptive rocks probably of Tertiary age, trachyte and felspar porphyry predominating, together with some serpentine.

The Cretaceous formation, chiefly limestone and clay-slate, covers a considerable area in this portion of the state of Guerrero. In a north-westerly direction, it reaches to Tasco (27 miles as the crow flies), and can be traced as far as Zacualpan (50 miles) in the State of Mexico; indeed,

patches of limestone of probably the same age are met with as far as Sultepec (63 miles), which three are historical silver-mining camps, Tasco and Sultepec being among the first districts explored by the Spanish *conquistadores*.

The quicksilver deposits may be divided into two classes :—

I.—Surface or shallow deposits (deposition mainly mechanical).

A.—Large loose deposits in limestone and gypsum-rocks worked mainly as opencasts.

B.—Small loose vertical pipe-like deposits in gypsum-rocks.

II.—Deep deposits (deposition chemical).

Large cylindrical deposits in limestone-rocks, occasionally opening out into lenticular or ellipsoidal chambers or pockets.

I.—Surface or Shallow Deposits.

A.—Fig. 1 (Plate I.) is a general surface-plan of the mines, including the large opencasts (*tajos abiertos*) known as Las Viejas, La Tumbaga, La Sorpresa, and Coahulote.

Las Viejas deposit has been worked 150 feet in a north-and-south direction, 100 feet east and west, and about 50 feet in depth as an opencast. At the bottom of the opencast there are underground workings to a further depth of 50 feet, making a total depth of 100 feet for this working. The dotted lines show the general direction of the main deposits worked, which generally corresponds with the longer diameters of the pipe-like holes in gypsum-rock which formed part of the large deposit, and which will be described later. This opencast is at present abandoned. It appears that stones of cinnabar, together with the black fibrous quicksilver ore known as *hebrudo* or barcenite (antimoniate of lime and mercury), were formerly raised from here in large quantities.

La Tumbaga deposit (Spanish for *pinchbeck*), close to the last, has been worked as an opencast for a length of 150 feet, a width of 50 feet, and a depth of 25 feet. Underground workings, started at the bottom, extend to a further depth of 40 feet, giving a total depth of 65 feet. The direction of the deposit appears to be north-north-east to south-south-west. *Buscones* or tributers were raising a good quantity of ore from here at the time of the writer's visit. The ore consists mainly of smalls or *tierras*, stained and spotted with cinnabar, together with a few *boleos* (or nodules) of *hebrudo* (which largely predominated in the upper portions of the deposit, but is now becoming very scarce), cinnabar, and stibnite, and many lumps and fragments of limestone veined with calcite and some quartz.

La Sorpresa (or Nananche) deposit has been worked as an opencast for 200 feet in length (north and south), 141 feet in width (east and west), and 20 to 30 feet in depth. There are somewhat extensive underground workings below this also, making the total depth of the deposit about 150 feet. Beneath this the ore is said to have given out, although the rock (mainly gypsum) in which it occurs continues farther down. The gypsum is associated with native sulphur. The ore occurs as *boleos* of *hebrudo* and some cinnabar (1 or 2 per cent., sometimes with much iron), mixed with small fragments of limestone, sand, clay, etc., in cylindrical and other cavities in gypsum-rock. This surface-deposit is intimately connected, if not identical, with subdivision B. The main axis runs north-north-east, or parallel to La Tumbaga deposit. *Buscones* were working here and raising about 150 tons of sandy smalls or *tierras* per week. The ore went deeper on the south than on the north side.

Between Las Viejas and La Sorpresa deposits is a small connecting opencast-working, trending north and south, and dipping west.

The Coahulote deposit has been worked as an opencast 180 feet east and west, 130 feet north and south, and about 20 feet in depth. In the bottom a shaft goes down 46 feet, giving a total depth of 66 feet. The ore is somewhat similar to the Sorpresa deposit, but is much mixed with clay. It contains spots and stains of cinnabar, and some *boleos* of light brown gypsum. Several lines of vertical holes are seen here running mainly in a direction diagonal to the general east-and-west run of the opencast.

The ore now being raised from the above opencasts (excluding Las Viejas) carries 0·4 to 1 per cent. of quicksilver, and the general average may be taken at ½ per cent.

When these deposits were first worked, the average grade was much higher. In 1874, the ore was divided into four classes, containing the following percentages of metal respectively:—No. 1, 15 to 17; No. 2, 8 to 9; No. 3, 5 to 6; No. 4, 3 to 4.*

B.—These deposits consist of ore, mingled with rock-débris filling natural vertical holes in gypsum, and are called *trojas de metal* by the miners from their supposed resemblance to the cylindrical adobe buildings used in this region for storing maize (*troja* being the Spanish for a granary). They are usually arranged along certain lines, thus, Los Colorados trend north and south, Las Trojas del Baco run nearly east and

* By Mr. Santiago Ramirez, *Noticia de la Riqueza Minera de Mexico*, 1884, page 445.

west, while another set courses north-east to south-west, and forms a junction with the latter. (See Fig. 1, Plate I., and, on a larger scale, Fig. 2, Plate I.)

The holes (*trojas*) are somewhat irregular in shape, occasionally being almost cylindrical, although usually having a longer diameter in the general direction of the line of holes, and thus forming an irregular ellipse in horizontal section. They vary much in size. Fig. 3 (Plate I.) is a sketch, drawn to scale, of one of these holes, which has been cleaned out of ore, and is now being used as a ventilating-shaft. The longer diameter (east to west) is 8 feet, while the shorter one is about 4 feet. Another *troja* was cleaned out, and then squared up to form a drawing-shaft. On the general plan (Fig. 2, Plate I.) a *troja* is shown, *A*, whose longer diameter measures 163 feet, while the shorter one varies from 20 to 45 feet.

Two very large irregular pear-shaped holes occur near the end of La Purissima crosscut. Near the present breast, a fissure in the limestone is seen crossing the tunnel, *i.e.*, trending east and west and dipping northward. Some of these holes contained no ore, but were filled with fragments of limestone, gypsum, sand, and clay, or general rock-débris. Several of the larger ones, however, contained a quantity of *tierras* with *boleos* of *hebrudo* (barcenite) mixed with rock-débris. The distribution of the ore, as in the large surface-deposits, was very irregular, although it is said that the larger lumps of ore were in several of the *trojas* found at and near the circumference of the hole.

The ore was found to diminish in depth, until it finally ceased at a limit of from 100 to 130 feet, a depth coinciding with the total or partial closing of the holes themselves, although the gypsum-rock was in some cases found to continue below.

The general plans (Figs. 1 and 2, Plate I.) only afford a faint idea of the number of holes in the gypsum-rock.

At a depth of about 130 feet from the surface, the Obra Palacio and the Obra Espiritu Santo have been driven below subordinate lines of these *trojas* in a general east-and-west direction. In the former, several dozen of them have been cut, a joint or fissure apparently linking them together. They are mostly of small size, and little or no ore of any value occurred in them.

Some of these holes are cylindrical, some are elliptical in plan, while others, again, are funnel-shaped, or conical, and do not reach the surface, the apex being uppermost. In some, the rock on the side of the holes appears to have been worn into rings or ridges projecting horizontally as if they had been formed by water having a violent rotary motion.

What is remarkable about the holes is their almost absolute verticality, while the gypsum-rock containing them is seen to be composed of a number of very thin horizontal layers, or, in other words, it is thinly stratified perpendicularly to the axes of the holes.

The probable origin of this rock, and of the pipe-like holes therein, will be discussed when considering the genesis of the deep deposits.

II.—Deep Deposits.

Up to the present date, only one of the deep deposits has been exploited in depth, although the probability is that other similar deposits exist in the immediate neighbourhood.

La Cruz Mine.—This deposit has been described as a *manto** or blanket formation, but from a careful study of the underground workings, it would, in reality, appear to be an inclined and somewhat irregular cylindrical deposit, here and there opening out into large lenticular or ellipsoidal chambers or pockets (*bolsas*) of mineral.

The longer diameter, which is termed the strike (*rumbo*) of the deposit, is directed north 52 degs. west to south 52 degs. east.† However, although the deposit sometimes trends more or less horizontally, it more frequently dips at a considerable angle in one direction of the so-called strike, *i.e.*, either north 52 degs. west, or south 52 degs. east. This dip, to prevent confusion, will be termed the "false dip" of the deposit. The true dip (*echado*) is flat, somewhat irregular above, and fairly uniform, or about 45 degs. towards south 38 degs. west below.

From the surface to a depth of about 100 feet, the deposit was capped by gypsum (*yeso*), and the ore was found mainly as *tierras* containing *hebrudo* (barcenite) in *trojas*, and filling cavities and pockets in the rock.

Below this upper zone, the first pocket of steel-grey livingstonite, sulphide of antimony and mercury, or 2 Sb_2 S_3 HgS, was found associated with stibnite in limestone-rock containing patches of gypsum, or in gypsum-rock containing unaltered patches of limestone.

The quicksilver ore, first described in 1874 by the Mexican geologist, Mr. Mariano Barcena,‡ much resembles stibnite in appearance, but the latter is whiter, and the former may be immediately recognized by its streak approaching wax-red in colour.

The pocket was lenticular in shape, and extended from just below Las Rosas to the Espiritu Santo workings. (Figs. 4 and 5, Plate I.)

* Mr. Santiago Ramirez, *op. cit.*, pages 93 and 444.

† The north shown in the plan is magnetic, variation 8 degrees east.

‡ *Tratado de Geologia*, Mexico, 1885, pages 138-139.

The length along the strike was about 147 feet; the width of the pocket on the dip was about 60 feet, while the actual thickness varied from a few inches to 1 foot in the upper part, where the ore was high grade, to from 5 to 6½ feet in the lower portion, a considerable fall of grade corresponding to the increase in thickness. The lower portion of the pocket appears to be ellipsoidal, with a false dip of about 35 degs. to north 52 degs. west. It also appears to be bifurcated, or to enclose a horse of rock, while the richest ore would appear to have occurred in the roof-branch. The average true dip was 40 degs. This pocket is stated to have yielded 30 tons of *pepena* or best ore (10 per cent. of mercury), and about 120 tons of ordinary ore (1½ per cent.) per week until it was exhausted. For about 32 feet vertically below this, the deposit was again flat (33 degs.), but too poor to work (or was *en borrasca*) when the second chamber or pocket known as La Esperanza was struck.

Its section on the line of the true dip is an irregular ellipse, with the axis inclined 60 degs. from the horizontal, and about 100 feet in length. The diameter measures from 30 to 50 feet. It is seen to be bifurcated, or to enclose a horse of rock from 25 to 32 feet in width.

While the true dip is 60 degs. as stated, the pocket has a false dip, the section on the line of so-called strike forming a narrow ellipse, with the axis inclined 30 degs. to north 52 degs. west, and 185 feet in length. The thickest ore again occurred in the roof-branch. The actual thickness of ore worked was about 6½ feet. Gypsum, with patches of limestone, occurred in the upper, while limestone predominated in the lower half.

The ore consisted of more or less solid crystalline livingstonite in gypsum and limestone, and was associated with native sulphur.

The ratio of *pepena* to ordinary ore and their respective yields were about the same as in the first pocket.

On the western side an exploratory drift was run in several feet, some small veins (*hilitos*) of livingstonite having been found running in this direction, but they were lost farther in the rock, and the work was abandoned.

For 197 feet measured vertically below this, the deposit was again thin and of very low grade (dip flat or 32 degs., and somewhat irregular), when, at the workings known as San Blas, the third and richest pocket was met with in solid dark-grey limestone. The latter is known to the miners or *barreteros* as *piedra azul* or *piedra aprieta*. On the line of the true dip it is seen to form an irregular ellipse, axis inclined 45 degs., length 164 feet, the diameter varying from about 30 to 75 feet.

It is also bifurcated, containing an irregular horse of rock impregnated with low-grade ore, portions of which have been worked out. The best ore occurs here on the floor-branch, while the roof-branch does not appear to have been worked continuously. Towards the upper portion and centre, about 30 feet of the pocket has been worked away (including the two branches), while in the lower portion 50 feet of it has been excavated in width. The average thickness was about 13 feet.

The pocket has a false dip of about 25 degs. to south 52 degs. east, or in exactly the opposite direction to that of the second pocket. The yield was 75 tons of *pepena* (12 per cent. mercury) and 225 tons of ordinary (1½ per cent.) ore per week.

Below this, the deposit has enlarged considerably, and is being worked out in immense chambers in solid dark-grey limestone-rock (*piedra aprieta*). It shows a tendency to widen below, the actual size and shape of the deposit at and near the bottom is, however, only shown approximately, as ore is being stripped down all round the workings. This lower portion of the quicksilver deposit would appear to be ellipsoidal in shape, with the axis dipping 45 degs. to south 52 degs. west. It also has a false dip of 60 degs. to south 52 degs. east. The ratio of the longer to the shorter diameter would appear to be as 2 to 1 —the former being along the so-called strike (*rumbo*), and the latter across the dip (*echado*).

The ore is more or less evenly disseminated throughout the whole mass, but is low grade, containing on an average only about 1 per cent. of mercury.* It consists of livingstonite (*metal antimonioso*), associated with stibnite (*antimonio*), selenite in transparent rhombohedral crystals, and native sulphur. Sometimes fine crystals of sulphur occur embedded in the selenite. Fine specimens of it, black and resinous as well as bright yellow and vitreous, are sometimes found in the limestone. In addition to the above minerals the limestone also frequently shows small cubical crystals of iron pyrites; it is, moreover, veined with calcite, and shows some quartz.

About 225 tons of ore of the above grade (1 per cent.) are being extracted from the lower workings weekly, which output could easily be doubled if necessary.

The main shaft or *tiro general* was 534½ feet deep at the time of the writer's visit, and was being sunk further for the purpose of communi-

* The assay of a large sample taken gave 1·14 per cent. of metal.

cating with the bottom workings (187 feet below the bottom of the shaft), total vertical depth then reached being 721½ feet. However, the mouth of the tiro trinidad, higher up the hill, is 98½ feet above the mouth of the tiro general, giving an aggregate vertical depth of 820 feet for this mine at that time (October, 1894).

The first portion of the main shaft is sunk in solid gypsum, but at a depth of 144 feet limestone with patches of gypsum occurs, lower down more or less solid gypsum with patches of limestone is seen, while solid limestone was encountered at a depth of about 380 feet.

Probable Genesis of the Deposit.

A careful examination of this very interesting and perhaps unique quicksilver deposit would seem to indicate that it was formed by a solfataric spring charged with mercury, antimony, and iron, cutting its way to the surface, and probably having a deep-seated origin in trachytic, porphyritic or other volcanic rock, similar to that cropping out immediately north and north-east of Huitzuco. The thermal spring, probably ascending the contact-line between the porous and impervious rocks, and subsequently making its way along joints and fissures (or following the lines of least resistance) in the limestone-rock itself, would appear to have deposited its metalliferous contents by preference in and around the denser beds, for here the solfataric spring must have taken longer to cut its way upward, and therefore there was more time for the quicksilver ore to be deposited. This would tend to account for the large pockets of livingstonite separated by low-grade ores, and also for their bifurcated character—for the spring would naturally cut its way around the denser masses of rock rather than go straight through them. On approaching the surface, after having deposited the greater portion of the mercury and antimony in the form of livingstonite and stibnite there would remain in the thermal waters an excess of sulphur, no doubt in the form of sulphuretted hydrogen. A part of the sulphur, probably reduced by organic matter in the limestone, has been deposited here and there in its native state during the long journey towards the surface. Another portion, mingling with the surface-waters, would become oxidized into sulphuric acid, which, attacking the limestone, has changed it layer by layer into gypsum or sulphate of lime, and for considerable distances on either side of the ascending spring until the surface was reached, forming the remarkable thermal channels known to the Guerrero miner as *trojas*. What sulphur remained would be eliminated in the atmosphere as sulphuretted hydrogen (H_2S) in a gaseous form, together with carbonic acid and steam.

Mr. Mariano Barcena was of opinion that the stibnite was first present in the rock, and that it was then decomposed by thermal waters containing iron and mercury under whose action the carbonate of lime was converted into sulphate and the stibnite into livingstonite.*

This theory was based on the appearance of the deposits at and near the surface, but it is hardly borne out by the deeper workings. On the contrary the two minerals have every appearance of having been deposited contemporaneously. The livingstonite, although frequently found in comparatively large pieces, is also often seen to be scattered through the limestone in minute crystals and specks; in fact, the rock is so permeated with it that it is difficult to believe that any previously existing stibnite (and there is probably nearly as much stibnite as livingstonite in the deposit) would have remained unaltered. It is more probable, indeed, that the two minerals were deposited in the reverse order, *i.e.*, after all the mercury had been deposited in combination with antimony, there would probably remain an excess of the latter metal, which would be subsequently deposited as stibnite pure and simple. Geologically, the two minerals may be regarded as contemporaneous.

That springs do actually cut their way to the surface through solid limestone-rock was proved by Mr. J. Nöggerath as long ago as 1845.

The following quotation is taken from the late Prof. Posepny's well-known paper on "The Genesis of Ore Deposits," published in the *Transactions*† of the American Institute of Mining Engineers for 1893:—

> At Burtscheid, near Aachen, . . . a terrace was constructed . . . in the neighbourhood of the hot spring as the site for a house. Blasting in the Devonian limestone exposed several vertical channels of nearly circular section, and 20 to 90 centimetres (8 to 35 inches) diameter, some of which contained thermal water and emitted steam. They had been partly choked by rock-débris, but one of them showed a depth of about 4 metres (13 feet). Immediately around these tubes the elsewhere solid limestone had been altered for a distance of 15 centimetres (6 inches) to a grey, earthy mass, almost plastic when damp, and separable in thin scales. In places this earthy mass had fallen away, and on the sides of the enlargements of the tube thus formed, crusts of white lime-sinter had been deposited‡ Prof. Nöggerath does not doubt in the least that the mineral water emerged 5 to 6 metres (16 to 20 feet) above the present exit, and eroded the channel for itself. He believes even that the channels of all the mineral springs of Burtscheid and Aachen, which came from the limestone, have a similar shape.

* *El Minero Mexicano*, vol. ii., 1874, page 399.

† Vol. xxiii., pages 241 and 242.

‡ Prof. J. Nöggerath, "Ueber die sogenannten natürlichen Schächte oder geologischen Orgeln in verschiedenen Kalksteinbildungen." Karsten's *Archiv. für Min., Geogn., Bergbau u. Huttenk.*, 1845, page 513.

Prof. Posepny was of opinion that the rich silver-deposits of Valle Sacca, near Rézbanya, Hungary, were formed by thermal springs precipitating successive crusts.

"In the principal deposit, the so-called Reichensteinstock, . . . argentite . . . predominated . . . besides this mineral there were hessite (telluride of silver), tetrahedrite, redruthite, galena, bismuthinite, and various pyrites. . . . The horizontal section of the body was most frequently circular or elliptical. In some places one dimension strongly predominated, so as to give the appearance of a fissure-filling."*

"The deposit occurred in limestone (Jurassic above and Liassic below) between greenstone dikes, and had a true dip eastward or parallel to the contact-line between the limestone and sandstone, which crops out to the east, and a false dip to the south. It was followed to a depth of 1,300 feet. . . . It is significant that the Reichenstein ore-channel passes in depth through the dikes to the south-west, towards what is probably a great fault-fissure, and not in the direction of the present drainage.

Prof. Posepny allows a similar origin for some of the more complicated ore-deposits of Raibl, in Carinthia.†

"One of the principal deposits (Government mine) occurs in Triassic limestone, and is roughly parallel to the contact-line between that rock and the Raibl slates to the north; but with steps or offsets in the direction of the slates, so that the deposit gradually approaches the contact-line in depth. . . . The ore consists chiefly of a coarsely crystalline galena, with pyrites, and a zinc blende (würtzite) in very thin crusts, hence called *Schalenblende*. . . . The ore-bodies have been followed to a vertical depth of 1,886 feet. . . . The three principal seams had a horizontal length of 131 to 262 feet, and a total thickness (including portions too poor to work) of 33 to 164 feet.

Prof. Posepny was also of opinion, contrary to that generally held, that the deeper lead-deposits in the Carboniferous Limestone of the North of England, and those of Leadville (Colorado), Eureka (Nevada), etc., were likewise formed by ascending thermal springs.

That the deep quicksilver deposit of Huitzuco was formed by a solfataric spring appears sufficiently clear when we take into account the local character and peculiar structure of the gypsum-rock, the frequent presence of native sulphur from the bottom workings upwards, the numerous cylindrical channels in the gypsum connecting the quicksilver deposit with the surface of the ground, the gradual increase in size and richness of the pockets as depth is attained, and the gradual increase in size of the deposit below the last pocket.

* *Op. cit.*, pages 287-289. See also *Geologisch-montanistische Studie der Erzlägerstätten von Rézbanya*, Budapest, 1874, in which Prof. Posepny, however, differs from his later conclusions by giving a vadose origin to the deposits.

† *Op. cit.*, 289-292. See also "Die Blei- und Galmei-Lagerstätten von Raibl in Kärnthen." *Jahrb. d. k. k. geol. R. Anstalt*, 1873.

There appears to be no distinct evidence of crustification, except may be in the flat and narrow portion of the first pocket. The ore appears to have crystallized out in the porous spaces of the limestone itself, and only appears in crystalline masses in the larger pockets. The ore, therefore, may be regarded as an impregnation-deposit.

It is probable that the deposit is parallel to, and in depth approaches the contact line of some eruptive rock, but at what depth this ridge occurs must for the present remain a mere matter of conjecture.

It is possible that other rich pockets of ore occur below the last, unless, indeed, the deposit continues downward as a large ellipsoidal or cylindrical ore-channel to the contact-line.

The infilling of the surface-deposits is most probably due to mechanical means, such as surface denudation of the limestone and gypsum, followed by the mechanical filling up of the depressions and vertical holes with rock-débris containing disseminated livingstonite and stibnite. Water carrying carbonic acid in solution has subsequently percolated through the loose débris, altering the livingstonite into barcenite, a portion of the stibnite into valentinite, and the iron pyrites into oxide of iron. The greyish-black columnar or fibrous mineral, known as barcenite, with its peculiar greenish ashy-grey streak has afterwards itself been altered partially (*i.e.*, in patches and spots when in large lumps) or wholly (when in small pieces) into red cinnabar.

Cinnabar is said to have occurred at Huitzuco, pseudomorphous after stibnite, and some fine examples of guadalcazarite ($6HgS + ZnS$) were found embedded in selenite, but both may be regarded as very rare.

That cinnabar has in several instances been deposited by hot sulphur-springs is positive knowledge. Messrs. Fuchs and De Launay say:—

> Les Steamboat Springs de Californie, les sources d'Ohaiawai en Nouvelle-Zélande, etc., déposent du cinabre; à la solfatare de Pouzzoles, M. de Chancourtois a trouvé du cinabre avec du réalgar; ailleurs, comme à Sulphur Bank (Californie), à Guadalcazar (Mexique), aux Bains de Jésus (Perou), en Perse, etc., des sources chaudes, chargées d'hydrogène sulfuré et d'acide carbonique, sortent de gîtes mercuriels.*

Mr. G. Becker is of opinion that the cinnabar-deposits of the Pacific slope (California) were deposited from hot sulphur-springs, probably in post-Pliocene times. At Yauli, Peru, hot sulphur-springs, depositing sulphur at the surface, are found close to cinnabar-deposits, and hot springs are also found near the Santa Barbara quicksilver-mines, Huancavelica, in the same country.

* *Traité des Gîtes Minéraux et Métallifères*, 1892, vol. ii., page 670.

Near Monte Amiata, in Tuscany, are several highly interesting cinnabar-deposits which have been examined by Messrs. Primat, B. Lotti, P. de Ferrari, and others. The latest writer on these quicksilver mines, Mr. R. Rosenlecher, says:— *

Diverse as the character of the deposits may be, their common origin from solfataric springs, which held in solution cinnabar and other sulphides, is evident, and they may be all ranged in the one category of "impregnation deposits." The hydrogen-sulphide springs and gas-wells, which still abound in the district, lend confirmation to this view.

At the Montebuono mine . . . Miocene sands overlie and conceal the Nummulitic Limestone. When the workings were driven down about 100 feet through the sands a great vertical crevice, 6 feet or so wide, was struck. It appears to split the whole mountain, and is no doubt one of the results of the ancient volcanic outbursts of Monte Amiata. This crevice is filled up with Miocene sands and clays impregnated with cinnabar in an extremely fine state of division, and in the immediately neighbouring rock are several funnel-shaped cavities, also filled with metalliferous sands and clays, the proportion of cinnabar increasing with the depth from the surface. On the whole, the average percentage [of metal] is 0·4 to 0·5.

These funnel-shaped cavities would appear to bear some analogy to the *trojas* of Huitzuco.

Again, at the Siele mine, . . . in Middle Eocene limestone and shales, . . . are . . . pockets filled with a dark grey clay, veined with calcite (*biocca*). In this are embedded iron pyrites and cinnabar, more or less concentrated at one point, or sometimes evenly dispersed throughout the mass. . . . The best part of a pocket is generally near its lower end, where it contracts funnel-wise into a narrow tube, through which, probably, the inflow of the metalliferous solutions took place. The average longitudinal extent of the pockets is from 160 to 260 feet, vertical from 130 to 160, and thickness 3¼ to 6½ feet.

At Guadalcázar, State of San Luis Potosi, the only other quicksilver deposit in the Republic of Mexico developed to any great extent occurs in Cretaceous limestone, bearing a strong resemblance to that of Huitzuco.

The ore is chiefly cinnabar associated with calcite and fluorspar and native sulphur occasionally, and is said to occur in the form of blankets (*mantos*) alternating with layers (*capas*) of greyish-black limestone, and having a general direction of north 40 degs. east to south 40 degs. west, and dipping 35 degs. north-west. Between the *manto* and the limestone there is generally a layer of gypsum; however, sometimes the roof or floor consists of ferruginous clay. Besides the *mantos*, the cinnabar is found as small veins or threads coursing through the limestone in various directions, or forming a kind of stockwork. Guadalcázarite occurs here associated with cinnabar, and livingstonite has also been found, but is scarce.

* The writer quotes from an abstract published in *Trans. Fed. Inst.*, vol. viii., pages 632-5, not having had an opportunity of consulting the original paper, which is published in *Zeitschrift für praktische Geologie*, 1894, pages 337-53.

Messrs. F. de P. Zárate and L. Floresi* say that—

The quicksilver zone near Guadalcázar consists of a band (*faja*) of limestone rock altered to a calcarous tufa (*toba caliza*), with openings or concavities (*abras* or *aquedades*), often acquiring large dimensions, and traversed by threads or small veins (*hilos* or *vetillas*) of gypsum, and according to Mr. Ramirez, the altered limestone alternates with more or less extensive beds of the latter rock. Such openings are generally filled with clays or gravels through which cinnabar is sometimes irregularly distributed.

The Sant Antonio de Padua mine was the deepest in 1878. One rich *manto* was met with at a depth of 65 feet, and another at a depth of 164 feet.

The eruptive of the district is a quartz-porphyry, and, as at Huitzuco, it comes to the surface at a considerable distance from the quicksilver-mines. At Guadalcázar, the porphyry-rock is traversed by numerous silver-bearing veins, while the felspar-porphyry hill about 2½ miles north-east of Huitzuco, known as Cuitlanapa, contains some veins and alluvial deposits of hæmatite.

Since Mr. Santiago Ramirez, the Mexican geologist, wrote his memoir† on these deposits, from which most of the above particulars are taken, considerable development work has been done on them by an English company, which cannot fail to throw considerable light on their probable origin. However, so far as the writer is aware, little or nothing of any scientific value has been published about the results of the later workings.

These deposits would appear to bear a considerable analogy to those of Huitzuco, and they, too, most probably had a solfataric origin. It would seem probable that the so-called *mantos* are in reality pockets connected together, and that the roof and floor of the deposit have been altered to gypsum by the sulphuric acid present in the spring, as at Huitzuco.

In the Cerro de San Cayetano in the same (Guadalcázar) district there is a curious so-called cave (*cueva*) in the limestone. The opening is in the form of an ellipse, 590 feet by 328 feet. It enters vertically to a depth of 20½ feet, and then dips 40 degs. for 656 feet. The whole of the limestone is coloured by, and here and there spotted with, cinnabar. Near Xochitepec, Cuernavaca (Morelos) is likewise a curious ellipsoidal grotto, and near the Cerro de Apaltaco, in the same district, there occurs

* *El Minero Mexicano*, vol. ii. (1875), pages 500-503.

† "Informe sobre el Mineral de Guadalcázar . . ." *Anales del Ministerio de Fomento de la Rep. Mexic.*, vol iii., 1877, pages 339-404. For the mercury-mines, see pages 395 to 402.

a spring of sulphuretted hydrogen of an elliptical form, the longer axis measuring 14 feet, and the smaller 9 feet. In the waters, carbonic acid is found besides sulphuretted hydrogen, and among the fixed substances are sulphate of lime, chlorides of potassium and sodium, and free sulphur (produced by decomposition of H_2S).

Here, then, we have positive evidence of a sulphur-spring having formed a channel in limestone-rock which is elliptical in cross section, and the two grottos mentioned above were most probably formed in like manner.

Method of Exploitation.

The system of working presents few features of particular interest. To a depth of nearly 300 feet the ore was taken along cross-cuts to the *plats* (called Despacho No. 1 and No. 2, Figs. 4 and 5, Plate I.) in the Trinidad shaft. Below this depth it is hoisted up the main shaft.

Some low-grade ore from the second pocket, too poor to extract, is packed in the mine, being walled round with deads (*tierra de limpia* or *tecoral*), forming what is called a *caja de limpia*.

As already stated, the ore in the bottom is being worked out in immense chambers. The rock (limestone) is so solid that no supports are necessary.

When the writer was at the mines, the ore was being carried by youths and boys (*tenateros*) to the bottom of the main shaft up a kind of staircase cut in the limestone. Wicker baskets (*chiquehuites* or *chicuites*) without handles, and strengthened at the bottom and sides with leather, were used for this purpose, being carried on the shoulders, and strapped across the forehead.

When the shaft is connected with the bottom workings this primitive method will be dispensed with, and safety-cages (here called *chalupas de seguridad*) will replace the present skips (*canastros*).

History.

The surface-deposits were discovered in 1873, and the deeper-lying livingstonite-deposit the following year. The first of the former discovered was that called El Coahulote de los Muertos (Coahulote of Fig. 1, Plate I.).

Mr. Thévenet purchased the mines of the discoverers (Mexicans) in 1874 and formed a company to work them, which, afterwards, coming to grief, was re-formed with the aid of fresh capital. The mines were

worked on the joint-stock plan for eleven years, when, in 1885, they were purchased outright by Mr. Romero Rubio, Secretary of the Interior, who has since worked them as a private concern.

The writer examined the mines in the interests of the present owner.

Yield.

There is no doubt that the mines have up to date yielded a large quantity of quicksilver, probably more than 30,000 flasks, but exact statistics are extremely difficult (if not impossible) to obtain.

During the first few years' working much quicksilver (probably 50 per cent.) was lost, owing to the crude means of reduction employed.

The Reduction-Works.

The ore is divided into four classes:—

1. High-grade ore or *pepena*, containing from 10 to 12 per cent. of mercury.

2. Low-grade or ordinary ore (*metal ordinario, comun*, or *desplobado*), containing about 1 per cent of mercury.

3. Middlings or *granzas*, of about the same grade as No. 2.

4. Smalls or *tierras*, containing about ½ per cent. of mercury.

No. 1 is usually treated in the same furnace as No. 2 or 3 according to its size, though the wisdom of this is questionable. A higher extraction would no doubt be effected by reducing No. 1 by itself in iron retorts with quicklime. Very little ore of this class was being extracted when the writer was at the mines.

Figs. 6, 7, and 8 (Plate I.) give the details of the furnace used for treating the ordinary or No. 2 ore. It was designed in California, and is similar to some of the furnaces used in the quicksilver-mines of that country. The shaft (*vaso*) is rectangular in horizontal section, and is about 19½ feet in height.

The ore is charged in large lumps, and undergoes a simple calcination. The fuel is firewood, which is burnt on fireplaces on the longer sides of the furnace, the heat and products of combustion entering the shaft down the inclined passages shown. The mercurial vapour, antimony fumes, etc., pass out near the top of the shaft and go down an inclined plane, and then through the condensing-chambers and up the inclined flue and stack.

There are two furnaces of the above design built side by side, only one of which was in operation last year. Each furnace has a capacity of from 675 to 750 tons per month. The charge amounts to about 1¼ tons at a time.

The mercury fumes, etc., pass a set of thirty condensing-chambers (*camaras de condensacion*) connected with each other alternately above and below, as usual, then along an inclined flue (*cañon*) about 426 feet long, divided up into horizontal divisions, and afterwards up a vertical chimney (*chimenea*) 32 feet high. A separate set of condensing-chambers is being built for No. 2 furnace (Fig. 2, Plate I.).

The air is drawn through the condensing-chambers by a Roots fan placed at the extremity of the last one.

Each furnace with 1 per cent. ore will yield about 100 flasks of mercury per month. About 90 per cent. of the quicksilver extracted condenses on the sides (*paredes*) of the condensing-chambers. The rest falls to the bottom (*piso*) with some antimony-oxide, soot, etc., forming a black ash (*ceniza*) containing about 30 per cent. of mercury in fine globules. This ash is put in a large sloping iron plate, a little water is sprinkled on it, and it is then scraped with an iron rake. When too wet quicklime is added. The residues, after washing, contain about 18 per cent. of mercury, and, it is said, 14 per cent. of antimony (as oxide). From 600 tons of ore about 9 tons of the washed residue will be obtained.

The residues are worked into round balls (*bolas*) by means of the clayey *tierras* from the Coahulote opencast workings, and are reduced with the smalls in another kind of furnace.

The loss in the calcination amounts to from 14 to 16 per cent. The smalls (*tierras*) are treated in a smaller furnace, containing at the bottom of the shaft (*vaso*) a number of fire-bars sloping against each other thus Λ, and spread out like a fan, or closer together above than below.

The ore is mixed with water until it is of the consistence of wet clay, and is then made into balls about 3 inches in diameter. These are dried in the sun in the *patio* or yard, and then stored in the *bodega* ready for calcination. The cost of making into balls, drying, and putting in the store-room, is about 50 cents (silver) per ton.

One man can make, on an average, 1·8 tons of *bolas* per day (extremes, 0·8 ton and 3 tons per day). It takes four days to dry the balls in the sun, or two days for each half exposed. The smalls containing much clay are mixed with others containing a good deal of sand.

The furnace having been well lighted with firewood and charcoal, is charged with 900 lbs. (or three *cargas*) of a mixture of balls and charcoal. Each charge consists of 300 lbs. (one *carga*) of *bolas*, and 25 lbs. (one *arroba*) of charcoal. The capacity of the furnace is about 225 tons per month.

The mercury passes into water-troughs at the foot of each of the condensing-chambers, and what remains uncondensed goes along a about 100 feet long, and then up a chimney 40 feet high, a wood fir the base creating the necessary draught.

A furnace of 225 tons capacity, treating ½ per cent. ore, will y from 50 to 60 flasks of mercury per month, the loss being from 10 t per cent.

The apparently high production is due to the addition of abo tons of *ceniza* from the larger furnace.

The burnt *bolas* (*tierras quemadas*) are brick-red in colour, extre hard, and contain only traces of quicksilver.

The middlings, or *granzas*, consisting of chips broken off wh smashing up the large pieces of ore with a sledge-hammer, are treated a double furnace of similar construction, together with larger sized bo (4 inches in diameter).

A certain proportion of *granzas*, namely, 1 part to 17 of *bola* is put in with every charge. Each double charge consists of about 1 tons in weight. The ore is first charged into a hopper on one side at t top. The outer door is then closed, and a door leading into the shaft i opened for the charge to fall down.

A furnace with a capacity of 525 tons per month of ore, containin ½ per cent. of mercury, will produce from 50 to 60 flasks.

The mine last year was producing about 200 flasks of mercury pe month, and was making a good profit with this product. With th second furnace running, the product would be about 300 flasks pe month.

By making alterations in the surface arrangements, by building tw small furnaces, and by introducing certain improvements in the treat ment of the ore, the product could, no doubt, be largely increased.

Whether it would pay to save the antimony from the low-grade ore a a by-product is questionable, considering the present low price of tha metal.

The quicksilver produced is consumed in Tasco and other silve districts of the republic. Each flask (*frasco*) contains 75 lbs. of quick silver, and was worth 60 (silver) dols. last October.

The writer does not feel himself at liberty to give details as to costs o mining, reduction, etc., or the actual amount of profit obtained.

The meeting was then closed.

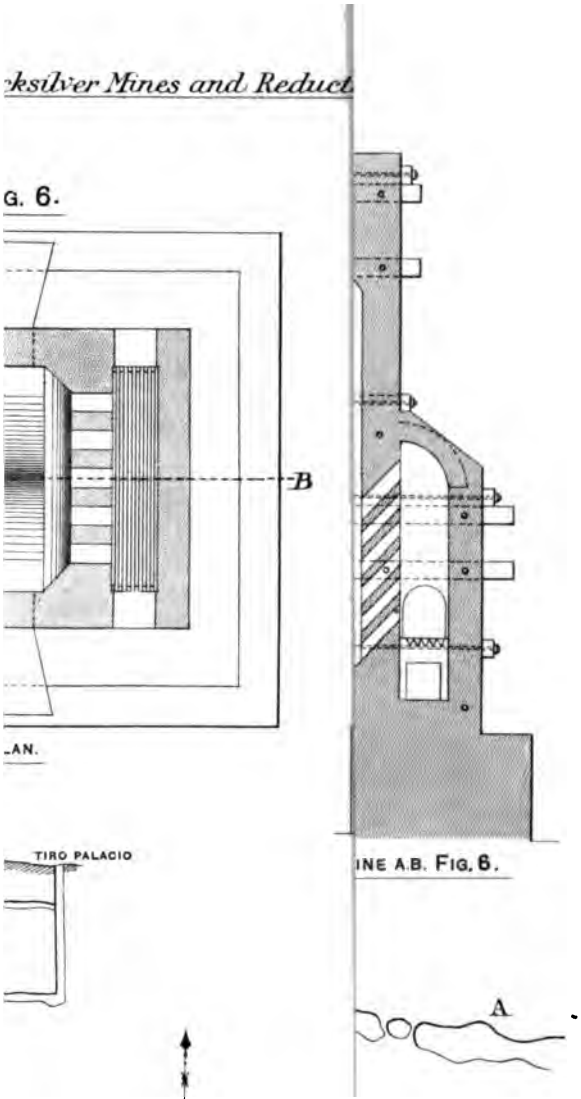
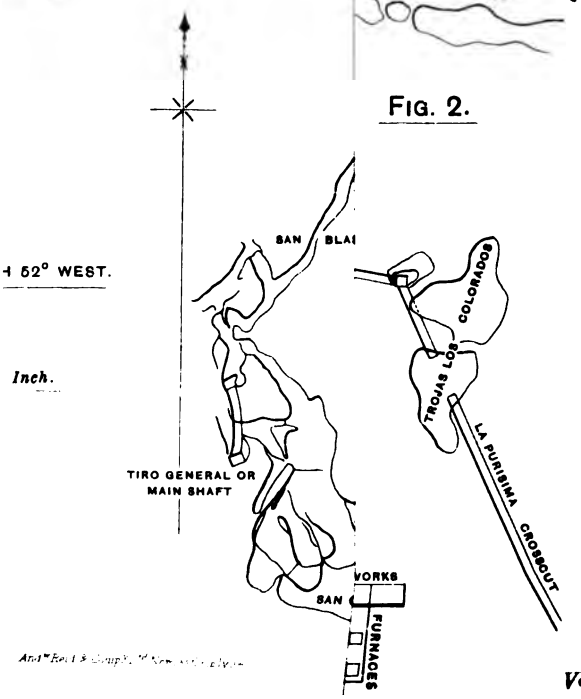

ksilver Mines and Reduct
G. 6.
B
AN.
TIRO PALACIO
INE A.B. FIG. 6.
A

FIG. 2.


52° WEST.
Inch.
SAN BLAI
COLORADO
TROJAS LOD
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MAIN SHAFT
WORKS
SAN
FURNACES

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT THE HARVEY INSTITUTE, BARNSLEY, AUGUST 7TH, 1895.

MR. J. NEVIN, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

Messrs. Holliday and Barron were appointed Scrutineers to count the votes given in the election of Officers.

The following gentlemen were elected :—

MEMBERS—

Mr. JOHN STANLEY DYSON, Land and Mineral Surveyor, Kirkburton, Huddersfield.

Mr. CHAS. WILLIAM FENNELL, Land and Mineral Surveyor, Wood Street, Wakefield.

Mr. GEORGE ROSCOE, Colliery Proprietor, Peel Hall Collieries, Little Hulton, Bolton.

The SECRETARY (Mr. Mitchell) read the Annual Report of the Council and statement of accounts as follows :—

THE COUNCIL'S ANNUAL REPORT.

The Council have pleasure in handing the members of the Institute their report on the work of the past year.

The following is a comparative summary of the number of members for the past two years :—

	1893-94.	1894-95.
Life Members	4 ...	4
Honorary Members	11 ...	11
Members	212 ...	210
Associate Members	3 ...	7
Associates	1 ...	8
Students	3 ...	6
Totals	234	246

showing a net increase of 12 in all classes over last year. It is hoped that the membership will for the future increase more quickly, as the subscription is small compared with the benefits received.

The following papers have been read during the past year:—

"Damage done by Lightning to the Surface Works at Garforth Colliery." By Mr. R. Routledge.

"Presidential Address." By Mr. John Nevin.

"A Detaching-hook used at the Sinking Pit at the Old Oaks Colliery." By Mr. E. W. Thirkell.

"Safety-lamps used at the Oaks Collieries." By Mr. E. W. Thirkell.

"Hargreaves Balanced Slide-valves." By Mr. Jas. Bowers.

"Hargreaves Piston." By Mr. Jas. Bowers.

"Internal Flaws in Steel." By Mr. Thos. Andrews.

"Designs for Pump-valves." By Mr. H. Wormald.

"The Garforth Collieries, with Special Reference to the Failures of the Tubbing and Inundations which occurred in 1872 and 1883." By Mr. R. Routledge.

"The Mexican or Patio Process of Reducing Silver Ores." By the President (Mr. John Nevin).

"Improvements in Exploders for Shot-firing." By Mr. H. Bonser.

"An Outburst of Gas at Mitchell Main Colliery." By Mr. W. Washington.

"Watering Underground Roadways, and a Lucifer Match at the New Oaks Collieries." By Mr. E. W. Thirkell.

The arrears of subscriptions for the year 1894-95 amount to £16 10s. or £9 less than last year. Of the £25 10s. arrears existing on June 30th, 1894, £9 have been recovered during the year 1894-95, £9 the auditors consider irrecoverable, leaving £7 10s. to be added to this year's arrears, or a total of £24, which in the opinion of the auditors will prove a realizable asset of the Institute.

In addition to the ordinary meetings held during the year, a joint excursion meeting with the Chesterfield and Midland Counties Institution of Engineers took place on September 27th at Shireoaks and Welbeck, and the thanks of the Institute are due to all those who contributed towards making the visit a success.

During the year the Institute has sustained a great loss by the death of one of the Past-Presidents, Mr. Joseph Mitchell, who for eleven years had been Secretary and Treasurer of the Institute; a memoir of his life has been prepared and presented by Mr. G. J. Kell.

The alteration of the day of the meeting to Saturday, while inconvenient to some members, has been productive of larger attendances.

The Council would again urge on all the members to use their influence in inducing eligible persons to join the Institute so as to increase the numbers, and also to contribute papers on any subjects which may arise in the course of their practice.

THE TREASURER (Mr. T. W. H. MITCHELL) IN ACCOUNT WITH THE MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS, 1894-95.

DR.

	£ s. d.	£ s. d.
1894.		
July 1.—To Balance at Bankers	58 17 9	
„ „ Cash in Treasurer's hands ...	1 4 5	
		60 2 2
1895.		
June 30.—To Subscriptions for 1894-95 ...	316 10 0	
„ „ „ paid in advance for 1895-96	6 0 0	
„ „ Arrears...	9 0 0	
		331 10 0
„ Sale of Dinner Tickets ...	8 10 6	
„ „ Members' portion of the Wine Account at the Annual Dinner	3 8 0	
		11 18 6
„ „ Sale of *Reports* of the Flameless Explosives Committee of the North of England Institute of Mining and Mechanical Engineers		7 3 0
„ „ Letting of Institute Room...		0 10 0
„ „ Bank Interest		1 13 6
		£412 17 2

July 26th, 1895.

Audited and found correct, { H. B. NASH. E. W. THIRKELL.

CR.

	£ s. d.	£ s. d.
1895.		
June 30.—By The Federated Institution of Mining Engineers:—		
Call of 17s. per Member on 231 Members for 1894-95...	196 7 0	
Special Call for 1893-94 . .	24 5 0	
„ By Excerpt *Transactions* ...	4 5 0	
„ „ Proportion of cost of Exchanging *Transactions* with other Societies	3 6 8	
		228 3 8
„ „ Annual Dinner		17 14 7
„ „ Printing and Stationery		10 0 8
„ „ Office Rent		12 0 0
„ „ Reporter		6 15 0
„ „ Insurance		1 11 6
„ „ Cleaning		1 6 0
„ „ Gas Company		0 6 8
„ „ Hire of Rooms for Meetings in Leeds and Sheffield		1 14 6
„ „ Secretary's Salary	£50 0 0	
„ „ „ Expenses ...	12 2 4	
		62 2 4
„ „ Chesterfield and Midland Counties Institution of Engineers—Moiety of Expenses of Joint Meeting, 1894		1 10 6
„ „ North of England Institute of Mining and Mechanical Engineers for *Reports* of the Flameless Explosives Committee ...		6 10 0
„ „ Stamps, Telegrams, Carriage, Wrappers, Post Cards, and Sundries		17 1 0
„ „ Balance at Bankers	£42 8 10	
„ „ Cash in Treasurer's hands ...	3 11 11	
		46 0 9
		£412 17 2

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL STATEMENT, 1894–95.

LIABILITIES.				ASSETS.					
1895.	£	s.	d.	1895.	£	s.	d.	£	s. d.
June 30.—None.				June 30.—By Cash in Bank	42	8	10		
Balance, being capital	429	4	9	„ „ „ Treasurer's hands ...	3	11	11		
								46	0 9
				„ „ Estimated Value of Instruments for Fan Experiments				12	0 0
				„ „ Value of *Transactions*, 6,890 parts at 1s. each	344	10	0		
				„ „ 18 Copies of Report of the French Commission on the Use of Explosives, at 3s. each	2	14	0		
								347	4 0
				„ „ Arrears of Subscriptions ...	...		...	24	0 0
	£429	4	9					£429	4 9

July 26th, 1895.

Audited and found correct,

H. B. NASH,
E. W. THIRKELL, } Auditors.

Mr. H. B. NASH (Barnsley), as one of the Auditors, moved the adoption of the report and balance-sheet, and referring to the fact that the balance in hand at the end of the year was £46 0s. 9d. against £60 2s. 2d. at the end of the previous year, said that was not at all a satisfactory state of things. It showed that more members were wanted to maintain the balance in hand, and he hoped members would induce their friends to join the Institute.

Mr. J. E. CHAMBERS seconded the motion, and said he thought the accounts very satisfactory, inasmuch as they had paid a special call of £24 5s. for the preceding year, also the call per member to The Federated Institution of Mining Engineers was 17s. instead of 15s., otherwise their position would have been better than it appeared.

The PRESIDENT said that during the past year they had also raised the Secretary's salary from £25 to £50, but for that they would have had a balance of £100 instead of £46.

The report and balance-sheet were adopted.

ELECTION OF OFFICERS FOR 1895–96.

The Scrutineers reported the result of the election as follows:—

PRESIDENT.

Mr. J. NEVIN.

VICE-PRESIDENTS.

Mr. J. LONGBOTHAM. | Mr. J. E. CHAMBERS. | Mr. G. B. WALKER.

COUNCIL.

Mr. A. A. ATKINSON.	Mr. H. B. NASH.
Mr. W. HOOLE CHAMBERS.	Mr. R. ROUTLEDGE.
Mr. M. HALL.	Mr. E. W. THIRKELL.
Mr. WM. HARGREAVES.	Mr. W. WASHINGTON.

SECRETARY AND TREASURER.

Mr. T. W. H. MITCHELL.

REPRESENTATIVES ON THE COUNCIL OF THE FEDERATED INSTITUTION OF MINING ENGINEERS.

Mr. A. M. CHAMBERS.	Mr. J. LONGBOTHAM.
Mr. W. E. GARFORTH.	Mr. G. B. WALKER.
Mr. J. NEVIN (*ex-officio*).	Mr. F. N. WARDELL.

BALLOT VOTING.

Mr. NASH gave notice that at the next Annual General Meeting he would propose that Rule 9 be altered, so that the election of council in future may be by ballot.

Mr. JOHN GERRARD proposed a hearty vote of thanks to the President, Vice-Presidents, members of the Council, and Secretary and Treasurer, who had so ably piloted the Institute during the past year. The members were especially indebted to them for having maintained the dignity, usefulness, and general lustre of this, one of the oldest Institutes of the country.

Mr. R. ROUTLEDGE seconded the motion, which was carried unanimously.

The PRESIDENT replying said that he was not entitled to the vote; the persons entitled to it were those who had attended the meetings, and especially the Secretary and Treasurer, who did the bulk of the work.

DISCUSSION ON MR. W. WASHINGTON'S PAPER ON "AN OUTBURST OF GAS AT MITCHELL MAIN COLLIERY."*

The PRESIDENT said that this outburst seemed very similar to other outbursts of gas which had been recorded. They had been fortunate in Yorkshire for many years in having outbursts of gas without accident to life, and it was important to have all of them recorded in the *Transactions*.

Mr. W. WASHINGTON said gas was still being given off in very small quantities, but the blower was now practically exhausted.

Mr. W. E. GARFORTH said he supposed that the pressure of the gas could not be ascertained.

Mr. WASHINGTON said that they had not been able to ascertain the pressure of the gas at the place where the outburst occurred.

The discussion was then closed.

Mr. G. BLAKE WALKER read the following paper on "The Roth Method of Firing Shots":—

* *Trans. Fed. Inst.*, vol. ix., page 289.

THE ROTH METHOD OF FIRING SHOTS.

By GEORGE BLAKE WALKER.

Much attention is being given just now to the use of safety explosives for blasting in coal-mines. The question of igniting explosives is also one with which mining engineers are much concerned, seeing that any method which produces sparks in the process of igniting the charge is almost as objectionable as the use of a naked light for that purpose.

The old method, of course, was by means of the simple time-fuse, and this is undoubtedly a convenient method where the presence of gas does not render its use dangerous. To enable fuse to be still used, an arrangement was introduced some years ago, for which it was claimed that any danger from sparks arising from the fuse was entirely obviated. Of late years, however, the electric detonator has become by far the most universal method, but it involves the use of an electric battery and a somewhat expensive form of detonator and attachments.

The writer has received from Dr. Roth, the inventor of roburite, a description of another method of discharging shots which he has invented, and which may be of interest to the members of the Institute. The principal features of the invention are: the use of (1) a small leaden tube, 0·04 inch (1 millimetre) in diameter, passed through the stemming, and (2) chlorine gas, which, generated in a suitable vessel, is allowed to pass through the tube to a detonator, which is charged with metallic antimony or other suitable material placed over the fulminate of mercury. When the chlorine gas reaches the detonator, it combines with the antimony, and thereupon considerable heat is produced, causing the explosion of the fulminate of mercury, and the detonation of the charge of explosive. The explosion of the detonator is therefore produced entirely by a chemical combination, and no spark or flame is produced.

The production of chlorine gas is effected in a very simple manner: A small bottle containing about 2½ grains of hydrochloric acid is connected with the detonator (already described) by means of a small tube. If a pilule of permanganate of potash is added to the hydrochloric acid, chlorine is produced, the gas passes up the small tube and produces the explosion of the detonator. The pilule of permanganate of potash is

inserted in a small papier-mâché tube which is closed with carbonate of zinc. The production of chlorine cannot take place until the carbonate of zinc has been decomposed by the hydrochloric acid, and thus the time which should elapse between the introduction of the pilule and the discharge of the shot can be regulated as may be desired, in order to allow of the safe retreat of the shot-firer.

A further advantage is secured by the action of the hydrochloric acid on the carbonate of zinc by means of which carbonic acid gas is produced, and displaces the air in the tube.

The process has been practically tested in Germany with very satisfactory results, the discharge of the shots being said to have been certain and occurring at the prescribed interval of time after the pilule had been inserted in the bottle.

It is claimed that this method is a cheap means of ignition as compared with the use of electric-detonators, but since a piece of leaden tube is destroyed with every shot, the writer does not feel very confident as to the correctness of this claim. The preservation of the chemicals in a pure state is also essential, and whether this could be secured in practice in the hands of colliery officials, such as the workmen to whom the work of firing the shots is entrusted, is another point which is open to some question. The method, however, is a very ingenious one, and worthy of the reputation of the chemist by whom it has been devised. The writer is endeavouring to obtain a set of apparatus, and will be pleased to lay the results of his experiments before the Institute when he has given it a practical trial.

Mr. L. T. O'Shea wrote that the heat evolved when chlorine and antimony come in contact with one another is considerable, and when the chlorine is good and in large excess the antimony becomes red-hot. Whether the heat evolved when a small quantity of chlorine, and that not pure, comes in contact with antimony is sufficient to ignite the detonator is a question for experiment. The idea of making chlorine in a mine is a novel one, and coming from Dr. Roth is worthy of every consideration. In the absence of a description of the Roth apparatus, criticism may seem premature, still he (Mr. O'Shea) was afraid that the process would be attended with more difficulties than appeared from Mr. Walker's paper. The odour of chlorine is extremely pungent and irritating. When the shot with detonator and leaden tube is ready for firing, the hole is firmly tamped, and the end of the leaden tube which is placed in the detonator

is practically sealed; on connecting the other end of the tube with the chlorine flask, the apparatus is full of air. Now, if the junction of the tube and flask be not air-tight, the chlorine will escape from the junction and will not go down the leaden tube; but if the junction be air-tight, how is the air to escape when the carbonic acid and chlorine gases are generated? Great pressure will be produced, and may result in breaking the junction; and if it does not break, he (Mr. O'Shea) imagined that it would take a long time for the chlorine to reach the antimony in sufficient quantity to generate the necessary heat. Then, also, unless the papier-mâché tubes are very carefully made, and the quantity of carbonate of zinc and the strength of the hydrochloric acid carefully regulated, the time required for the acid to reach the potassium permanganate will vary. Dr. Roth has doubtless overcome the practical difficulties, and he awaited the arrival of the Roth apparatus with much interest; but knowing how easy it is for the simplest chemical experiment to fail in the lecture-room, he (Mr. O'Shea) felt very doubtful of the success and regularity of one when carried out in the mine.

Mr. J. GERRARD (Manchester) said that any improvement in shot-firing would be welcomed by the members, because although electric firing was an improvement upon the so-called "safety fuze," it was not perfection. The number of failures with detonators was small, yet their possibility caused a little uncertainty and anxiety with regard to their use. He had pleasure in moving a vote of thanks to Mr. Walker for his paper.

Mr. A. A. ATKINSON seconded the vote of thanks and asked if Mr. Walker had definite information that the combination of chlorine with antimony would produce flame?

Mr. G. B. WALKER said that it was not a question of flame: by combination with chlorine the antimony became red hot and exploded the fulminate of mercury. The antimony was placed in the capsule of the detonator, and all heat or flame was produced at the inner end of the shot-hole. He thought that in a system depending upon the application of two chemicals, failure to act, and consequently missed shots, might arise more readily than with the electric system.

The motion was agreed to.

Mr. RANKIN KENNEDY read the following paper on "Electrical Machinery for Mines":—

ELECTRICAL MACHINERY FOR MINES.

By RANKIN KENNEDY.

This paper is intended to bring before the Institute some new forms of machinery specially designed for applying electricity as a motive power in collieries, and to discuss both continuous-current plants and alternating-current plants from a comparative point of view.

Continuous-current plants have hitherto been almost exclusively used in this country, in the few instances where electricity has been introduced, and at the present moment (when electricity is being more extensively used) continuous-current plants still seems to be preferred. Alternating-current plants are, however, doing good work in Europe, in the Colonies, and on a greater scale in America.

There are several reasons apparent to the author for the exclusion of alternating-current machinery from colliery workings in this country :— (1) Patent rights, which prevent those who make mining plants from dealing with alternating-current motors. (2) Continuous-current machine makers have been longer established, are better known, and have carried out all the work hitherto required. (3) The doubt as to whether alternating-current has any advantages over continuous-current plants. The first two causes may be dismissed with the remark that time will effectually and entirely remove them.

The third objection will now be examined critically, as the author's experience points to the conclusion that both systems have their good and bad points in certain cases. Under certain circumstances, alternating-current plant would have many great advantages, making its adoption a necessity. Under other circumstances, continuous-current plant may be the most advantageous, or be equally as good, in which case it would be adopted, for if the two are equally good for the case in consideration, the continuous current would be preferred on account of its being better-known and tried.

In some instances a combination of the two systems would be best; in fact the author believes that in every case a combination of the two systems would meet every requirement in transmitting power and distributing light about collieries, and the machinery to be described in this paper is, part of it, designed for use in such a combined system.

By recent improvements, incandescent lamps of high quality can be obtained at cheap prices to work at an electric pressure of 200 to 250 volts. There are already instances where electric motors are worked successfully in collieries at pressures of 500 volts. It is almost absolutely necessary to work motors at this high pressure to save copper in the cables or mains, while 250 volts is the highest pressure at which known lamps can be used. These facts point to the necessity of using two generating plants, one to give 250 volts for the lamps and the other to give 500 volts for the motors; or a three-wire system may be adopted with two dynamos in series, as usually worked in municipal generating-stations with very doubtful results. In any case, two circuits must be provided, one working at about double the pressure of the other. In laying out a plant for a colliery, these pressures must be very carefully considered, for once placed, the pressure in a continuous-current plant is unalterable except by the expensive process of discarding the generators, lamps, and motors, and replacing them with new ones.

A pressure varying from 200 to 250 volts seems to be best for the lamps, and the copper conductors to feed the lamps at these pressures will be only half the weight of those required for lamps at a pressure of 100 to 120 volts.

The two pressures may also be obtained from one dynamo with a double-circuit armature and two commutators, one at each end of the armature, but all these methods are expensive both in first cost and in maintenance. A better and cheaper method is to obtain the two pressures from one dynamo, with one commutator and without any complication of parts.

For this purpose a dynamo with four poles may be used, if only two pressures in two circuits are required (Fig. 1, Plate II.). It will be seen that it differs from an ordinary four-pole machine in the disposition of the poles; in an ordinary machine, the poles are placed alternately north and south (N, S, N, S), while in this machine the poles are arranged with two north poles (N, N) above the armature, and with two south poles (S, S) below it. In the ordinary machine, the four brushes are coupled in pairs, two north brushes together and two south brushes giving one current, or they may be coupled through the winding into two brushes at right angles giving one current. In the double-current machine, the two brushes under the gaps between the north poles (N, N) and south poles (S, S) are coupled together to form an intermediate circuit, while the other two brushes form the other circuit at twice the pressure, and thus the three-wire double-circuit system is

worked from the one machine with the same effectiveness as from two, while first cost, maintenance, and attendance is obviously reduced. The efficiency of one machine is higher than the efficiency of two coupled together electrically, as there is only one exciting circuit and one mechanical drive to be maintained.

Three dynamos should be sufficient for any colliery : one for the constant daily work of haulage, pumping, and lighting underground another for additional lights at night-time or any additional work ; and a spare dynamo for use in case of accidents to either of the others.

On this system the motors would be continuous-current motors, and therefore would have brushes and commutators liable to sparking and requiring attendance. The liability to sparking is no drawback, if there be no danger of firing gas in the mine, and the attendance on a good continuous motor need not exceed 10 minutes at intervals of once or twice a week if the load be constant (say driving a pump), but if the load is variable (such as hauling or coal-cutting) the attendance should be continuous.

As most places in mines are subject to accumulations of gas, an absolutely non-sparking motor is a necessity for all underground work except, perhaps, at the bottom of the down-cast shaft.

The motors at present used in continuous-current plants for driving machinery in collieries, for haulage, coal-cutting, pumping, etc., in the workings are generally boxed in airtight casings to prevent gas from being ignited by the sparks at the brushes. This system seems to be effective, as no case of igniting gas has occurred ; but assuming that the enclosure is effective, in practice every electrical engineer has a feeling that the brushes and commutator should be readily accessible, and they cannot be so in any of the enclosed systems. This is one of the weak spots in the continuous-current system. Another weakness is the fixity of the pressures. In cases of long-distance transmission (and they are the rule, not the exception) the pressure cannot be raised or lowered as desired. These two points are the only serious obstacles to the general adoption of the continuous-current system.

Some engineers shut their eyes to them ; others see them clearly, but hold them of no importance, while others again exaggerate these difficulties. It is admitted, however, that the sparking of continuous-current motors is an inevitable fact, and that enclosure is not a satisfactory solution of the difficulty. The fixed pressure in many cases is no drawback, save where the distances are long and higher pressure than 500 volts is necessary in the line wires. It is a question for the electrical

engineer in charge of the work to decide whether he can gain by higher pressure, and if higher pressure be required the alternating-current system should be used.

Polyphase Motors.—The alternating-current system, if ever used, will undoubtedly be a polyphase system, in which polyphase alternators with continuous-current exciters will be used for generating the currents in two or three phases. The motors will be without commutators or brushes, and consequently sparkless, and will not require to be enclosed. In this system the pressures are not fixed, and any pressure desired (high or low) can be obtained with certainty and efficiency by a transformer, which is no more complicated than an electro-magnet. These statements sound as if an ideal system had been reached; theoretically, it may be so, but in practice it has not hitherto reached the theoretical limits. Firstly, the generators are more costly than continuous-current generators, and the necessity for separate continuous-current exciters is a serious drawback; secondly, the motors at present available are more costly than an enclosed continuous-current motor. Polyphase motors require sliding-contacts and brushes, to insert resistances when starting, consequently the claim falls that they are without commutators. It must be evident that, so long as a single sliding-contact remains, the motor is no better than a continuous-current motor. It is possible to make this system a success, both electrically and commercially, and in time no doubt these various drawbacks will be overcome.

The author is not here treating of polyphase motors or systems generally, but is considering them solely as motors for use in mines where gas accumulates. Polyphase motors and systems have a much wider field of application.

Where small motors of less than 15 horse-power are required, the Kennedy polyphase motor can be applied successfully without the use of sliding-contacts, and can be adapted to the working of pumps and coal-cutting and haulage machinery underground with perfect safety; and for larger powers the same motor may still be used without sliding-contacts if allowed to start under a small load, by using a friction-clutch or fast-and-loose pulley.

The field-magnet (Fig. 2, Plate II.) consists of two circular rings A carrying inwardly-projecting poles, and around these poles are laid the exciting coils *B*. One alternating-current is led into one of the circles of fixed coils *B*, and the other alternating-current is led into the other ring of fixed coils *B'*, and the working currents simply flow through the fixed coils and enter by the fixed terminals. The armature (Fig. 3,

Plate II.) consists also of two parts, viz., two slotted laminated iron cores on one spindle (wound like an ordinary drum-armature, *C*), each complete coil being coupled across to a complete coil on the pole-armature *D*, and forming complete circuits in themselves.

In this machine the winding on the pole-armature acts as a secondary induced circuit to the field-magnet coils under which it is placed, the magnet coils acting as a primary-transformer circuit in fact; the one end of the machine is purely a transformer with its secondary revolving. The secondary induced currents flow through the windings on the drum-armature, and their phase coincides with that of the alternating-current in the coils of the field-magnet under which they are placed: a torque is therefore set up, as in a continuous-current motor.

The chief difference between this and other polyphase motors is that the two currents are quite separate on the motor, and therefore do not interfere electrically with each other, and as the self-induction of the one prevents a rush of current through the other, they mutually protect each other, and hence no sliding-contacts are required for introducing protective resistances.

A somewhat similar machine has, since its invention by the author, been introduced in America, where it seems to have met with great success.

In the combined system, the author proposes to use a modified continuous-current generator, capable of supplying continuous-current and polyphase-current simultaneously. After adopting such a generator, the mining engineer can at any time use either continuous, alternating, or polyphase motors, and he is not restricted to the use of any one class of motor, as in the case of an alternating or a continuous-current generating plant.

This advantage is a very important point, and one which may be illustrated by a case recently met with by the author. The owners of a colliery had, some years ago, erected a 60 volts generator, which satisfied them at the time, but subsequently they extended the electrical plant; meanwhile, however, they had heard of the saving to be effected by the use of high-pressure conductors, consequently additional motors and generators were selected to work at 110 volts, because at that time incandescent lamps were worked at that pressure. Still later, the same proprietors erected generators and motors for a pressure of 250 volts, and more recently they adopted 500 volts as the pressure of their last additional plant for transmitting power. In such a plant it is obvious that (although only a few years old) the earlier machines are obsolete, and

even now the most recent improvements cannot be adopted with such generators. If, in the first instance, a combined system had been adopted, the proprietors could at any time adopt improved lamps or motors, either for continuous or alternating currents. Whatever system of working is adopted no mining engineer should adopt generators incapable of supplying any kind of current which may be required in the future.

A generator capable of supplying continuous, alternating, and polyphase currents may be made as simple, cheap, efficient, and reliable as the continuous-current dynamo, being in fact the same machine with a few simple modifications.

Universal Dynamo.—The field-magnets are of the ironclad multipolar type, magnetized by one central coil of wire. Fig. 4 (Plate II.) is a sectional view showing the field-magnet and coil *C*, armature *A*, and commutator *B*. All the poles on one side are similar. There are two armatures, although wound as one, that is, there are two cores, one under each side of the poles. Fig. 5 is an end view of the generator, showing poles, coils, and armature. The cores are carried on a drum, keyed to a shaft. Gramme-winding is preferably used for small machines, and a drum series-winding is invariably used for large machines. The commutator *B* is of ordinary construction for continuous-current, and to furnish alternating-current, four slip-rings (*D*, *E*, *F*, and *G*) are insulated on the commutator. They are connected to four plates on the commutator, at right-angles to each other, and each ring makes only one contact. Brushes applied to these rings draw off the alternating-current as required. There is no external magnetism around this machine. It is shunt-wound; it may be compound-wound when desirable, and then becomes perfectly self-regulating.

This generator will supply a continuous current at 200 to 500 volts if desired, and it will also supply two alternating-currents in quadrature-phase. The owner is then furnished with a dynamo from which he can draw any kind of current that he may in future find it necessary to use, instead of having to erect a new plant if a different current be required.

The author has now described two plants containing the latest developments, for use in transmitting power and distributing light: (1) the continuous-current system with a two-pressure generator and enclosed motors; and (2) the combined continuous- and alternating-current system, with a generator capable of producing both kinds of currents, so that either one or both kinds of motors may be used at any time, and high or low pressure current can be readily obtained from the alternating circuits of this combined system by the use of transformers.

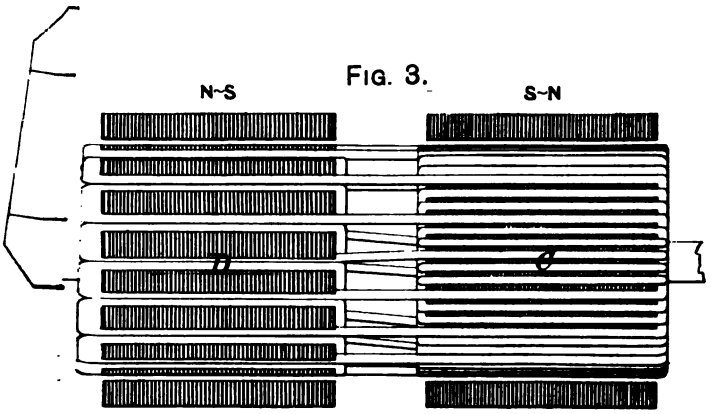
Electric Pump.—The author and Mr. Crawshaw have recently introduced a form of electric pump of small power. It works on a combined continuous and alternating-current system, and is designed for use in dip workings. The motor has no commutator, and what is perhaps of equal importance, no gear.

In the reciprocating percussion rock-drill (Fig. 6, Plate II.), an iron core *B* attached to the drill is drawn back into a solenoid of copper wire *A* by the electric current, and is then shot forward by reversing the current, and thus strikes a blow like a miner's pick. The Marvin and Van Depoele forms of these electric drills are probably the best known. In these rock-drills the simple solenoid and plain iron core are applied, the object being to get a smart forward blow and a slower drawback motion; but all of them are inefficient, because a wire solenoid and a plain iron core form the most defective of all combinations designed to convert electrical energy into reciprocating motion.

In the electric pump, a solenoid and core of improved construction are applied to work the pump-piston *P* to and fro at a comparatively slow rate and with considerable power. The solenoid *A* consists of a coil of copper wire (Fig. 7, Plate II.) enclosed in a casing, it carries the continuous current which magnetizes the casing, forming two powerful north and south poles, or produces a powerful magnetic flux through the iron core *B*, a flux equal to 22 kapplines per square inch of section of core. The core is about four times as long as the solenoid and carries two coils or solenoids, which are connected in series, so as to form two similar poles one at each end of the core and an opposite pole in the middle. The coils are supplied with alternating current and cause the core to move to and fro at the frequency of the current in the coils, so that if the pump is to make 60 strokes a minute the frequency of the current should be 60 per minute. The core and solenoid act similarly to a synchronous alternating motor, inasmuch as the motor tends to move at the same rate, whatever the load may be, provided that the number of turns of wire in the coils of the core are properly calculated, and the back pressure produced in the coils by the motion in the field regulates the speed. Provision should be made to avoid the effects of momentum produced, when the pump runs without water, but even then the strokes of the pump will remain constant, although they may be stopped at the end of each stroke with too great force. This is, however, easily remedied by means of an air-cushion or dash-pot.

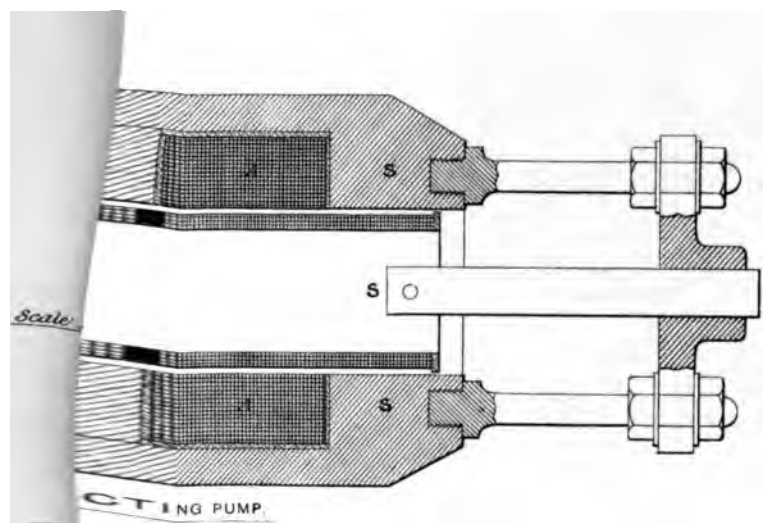
Efficiencies of Dynamos, etc.—The double-circuit two-pressure dynamo for working lighting circuits at, say 200 volts and motor circuits at 400

FIG. 3.



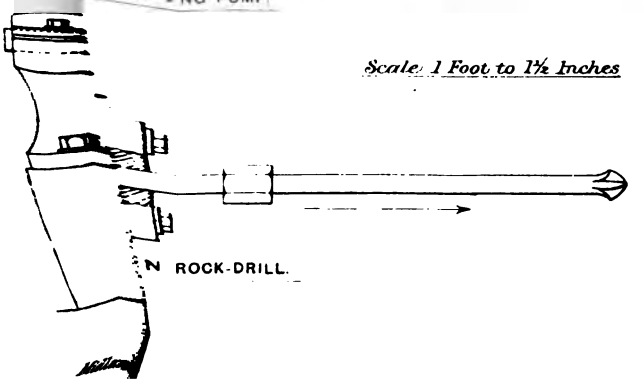
SECTION THROUGH ARMATURE.

Scale 1½ Feet to 1 Inch



NG PUMP.

Scale 1 Foot to 1½ Inches



N ROCK-DRILL.

volts, being of ordinary design, and acting on precisely the same principles as the common single-circuit generator, has the same high efficiency, 90 per cent. or more of the energy applied to drive it being returned as electrical energy.

The universal dynamo for generating continuous and polyphase currents simultaneously is also a machine essentially of high efficiency, being an ordinary design of dynamo so far as the armature and field-magnet are concerned, and the efficiency can also be made as high as 90 per cent. or more.

The polyphase motor, at one-fourth of its full load, has an efficiency of 75 per cent.; at half load, 85 per cent.; at full load, 90 per cent.; the fall of speed between no load and full load is only 3 per cent., and the starting torque can be made 2·5 times the full load torque.

The reciprocating electric pump has not a very high efficiency if compared with a rotating motor, but when compared with a rotating motor geared-down to drive a reciprocating pump, it then has quite as high an efficiency. The gearing interposed between a high-speed motor and the necessarily slow-speed pump generally wastes more power than the pump itself, so that in few cases of small pumps driven by a rotary motor, does the efficiency exceed 30 per cent. The reciprocating electric pump may not exceed this efficiency, but it has the advantage of eliminating all gear and its attendant troubles, an obvious improvement.

With old fashioned designs, and even with some recent designs of motors, it is necessary to assume a plant efficiency of only 33 per cent., that is, if 2 horse-power be required a 6 horse-power motor should be erected. It is very desirable to provide an ample margin of power, but with well-designed machinery a large margin is unnecessary, and a plant efficiency of 50 per cent. should be ample in all cases.

In conclusion, the author desires to direct the attention of mining engineers to the following points:—(1) The advantage of adopting an electric dynamo capable of delivering any kind of current, so that continuous or alternating motors may be used, together with transformers when found necessary; (2) if generators of this class be used, engineers can adopt all improvements that may arise in the future; and (3) the great flexibility of a mixed system working at collieries.

Mr. G. Blake Walker said that until the polyphase system was put before the members in a practical shape in South Yorkshire—where gas had always to be taken into account—until they got dynamos and motors on this principle they would be deterred from using electricity on

a large scale. With continuous-current dynamos there was always the objection of sparking, and he attached little importance to the security sought to be obtained by enclosing the commutator. Abroad, polyphase motors were being adopted more frequently than continuous-current machines, and he believed that the difficulties in their use were being overcome. If the dynamo had an efficiency of 90 per cent., and the current passed through two transformers, each losing 7 per cent., or 14 per cent. together, and there was further loss in the motor, the efficiency would fall to 75 per cent. Mr. Kennedy spoke of the transformers being a simple, inexpensive arrangement, but on a large scale he scarcely thought that correct. His opinion was that an alternating-current plant, including transformers, would cost twice as much as a continuous-current plant, although the cost of cables was reduced.

Mr. KENNEDY said the cost of transformers was about £2 10s. per horse-power; in a small plant the cost would be more, and in a larger plant it would be less. It was not always necessary to use a transformer with an alternating current, but with continuous current a transformer could not be used. The cost of ordinary continuous and alternating-current plant in compact places was about the same per horse-power, but for long distances the continuous current was much more costly. The chief advantage of the alternating current was that it enabled them to raise or lower the pressure as they found it necessary at any time. and to use commutatorless motors.

Mr. E. W. THIRKELL moved a vote of thanks to Mr. Kennedy for his paper.

Mr. GARFORTH seconded the motion, which was agreed to.

The annual dinner was held in the evening at the King's Head Hotel.

OBITUARY OF JOSEPH MITCHELL.

By G. J. KELL.

Mr. Joseph Mitchell, of Bolton Hall, near Rotherham, was the eldest son of the late Mr. Joseph Mitchell, of Swaithe Hall, Barnsley, and of Anna, daughter of the late Mr. Binns, of Wentworth. He was born at Worsbro' Dale, near Barnsley, on September 7th, 1840.

He served his apprenticeship with his father, who, besides being a colliery proprietor, carried on the iron foundry at Worsbro' Dale, and was also engaged in sinking pits in the district, thereby affording his son a varied, practical, and valuable insight into all matters relating to his profession of a mining, civil, and mechanical engineer. On the death of his father he assumed the entire management of the foundry, which has for many years supplied the collieries in the district with engines, boilers, etc.

Mr. Mitchell was engaged in the sinking of Mitchell Main colliery, where a very large quantity of water was encountered, and eventually dealt with successfully by him. His engineering knowledge was of great service in laying out the plant, sidings, etc., at this well-known and extensive colliery.

Mr. Mitchell rendered valuable assistance at the lamentable explosions at the Edmunds and Swaithe Main collieries, the latter of which he took charge of and put into working order, after overcoming great difficulties, requiring constant attendance and skill. He also rendered valuable help at the unfortunate explosion at Wharncliffe Carlton colliery in 1883.

Mr. Mitchell was appointed secretary of the Midland Institute of Mining, Civil, and Mechanical Engineers in 1879, and he helped most materially to raise the status of that Institute. He attended with a deputation and gave evidence before the Royal Commission on Accidents in Mines. In 1881 he contributed a valuable paper on "The Outburst of Gas at the Mitchell Main Colliery."* During his tenure of office many important experiments were carried out in connexion with safety-lamps, in which he took a very active part. In recognition of his eminent services, he was appointed president of the Institute in 1890, and retained that post until 1892, during which time he rendered signal service in all matters relating to the well-being of the Institute.

Mr. Mitchell took deep interest in local matters: he was a member for seventeen years, and chairman for fourteen years, of the Wombwell Local Board. During his term of office, the Wombwell sewage scheme was initiated and the gas-works purchased. He was always ready and willing

* *Trans. Midland Inst.*, vol. vii., page 212.

to do all in his power to better the condition and happiness of those arour him. His valuable knowledge and advice were eagerly sought after, a led to his being retained either as umpire, arbitrator, or witness in mo of the important cases in the district and elsewhere. He was a great su porter of all railway or canal schemes at all likely to benefit the district.

It is largely through Mr. Mitchell's foresight and knowledge tha the people of the township of Worsbro' are indebted for a supply of wate from the Barnsley corporation. Owing to the scarcity of water in th Wombwell district, he applied, in 1879, along with others, to Parliamen for acquiring water from the Oaks rock; although unsuccessful in the firs attempt, he persevered in his efforts, and finally succeeded in obtainin the bill in 1880. He had the satisfaction of seeing the works opened i 1884, whereby a population of 40,000 persons was amply supplied wit water at an outlay of £32,000.

Two years ago he arranged to take 2,500 acres of the Barnsley coal seam at Grimethorpe, near Barnsley, from Mr. F. J. S. Foljambe. Th sinking was commenced on October 8th, 1894, with the idea of developin a large coal-field, which will add materially to the wealth of the district as well as giving employment to a large number of workmen.

Mr. Mitchell was an active member and past-master of the Friendl Lodge, No. 1513, of the Ancient Order of Freemasons ; a governor of th Yorkshire College, a member of the North of England Institute of Minin and Mechanical Engineers, fellow of the Geological Society of London a member of the Iron and Steel Institute, a vice-president of The Feder ated Institution of Mining Engineers (in which he took particular interest and was one of the promoters), and a member of the Board of Examiner for the Yorkshire and Lincolnshire mining district. Mr. Mitchell wa also director of several companies. He was appointed a justice of th peace in 1892 ; indeed, few men have led a more active and useful life.

Mr. Mitchell married, on April 29th, 1862, Kate, daughter of Mr George Howe, of Boulogne-sur-Mer, France, who survives him, with thre sons and one daughter, the eldest of whom, Mr. T. W. H. Mitchell, succeed him in the management of the various concerns in which he was engaged

Mr. Mitchell will be greatly missed, not only by his own family, bu by a host of personal friends, workmen, and the public generally, as h was ever ready to give advice and assistance to those in need.

He was most genial and faithful to all his friends, and nothing coul exceed his hospitality at Bolton Hall, where he rejoiced to have then around him. He will be deeply mourned by all who had the pleasur of acquaintance with a man of such varied and good qualities.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE ROOMS OF THE ROYAL SCOTTISH SOCIETY OF ARTS,

EDINBURGH, AUGUST 10TH, 1895.

MR. GEORGE A. MITCHELL, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected:—

FEDERATED MEMBERS—

Mr. HERBERT PHILLIPS, Salisbury, Mashonaland, South Africa.

Mr. JAMES RITCHIE, Gartness Colliery, Airdrie.

The *Transactions* of the former meeting not having been issued to the members, the discussion of Mr. Allan Stirling's, Mr. A. M. Grant's, and Mr. J. G. Barclay's papers was adjourned.

DISCUSSION ON MR. G. A. MITCHELL'S PAPER ON "ELECTRIC COAL-CUTTING AT GLENCLELLAND COLLIERY."*

Mr. JOHN HOGG (Cambuslang) said that about three years ago, he saw a Goolden electric coal-cutting machine working in a colliery in England, and he would give a few particulars, which might be compared with the results stated by Mr. Mitchell.† The machine worked 7 minutes, cut 22½ feet, and then stopped for 17 minutes. It worked for 3 minutes and cut 6 feet. It then stood for 10 minutes, while they relieved the cutter, and worked for 7 minutes, cutting 30 feet. After standing 14 minutes, it was restarted, but was stopped again, so as to relieve the gearing. He did not stay to see its future progress. The machine could cut the coal at the rate of 3 feet per minute. Mr. Mitchell stated that at Glenclelland colliery the machine easily cut 3 feet

* *Trans. Fed. Inst.*, vol. ix., page 128. † *Ibid.*, page 133.

in 1½ minutes. The important matter was the irregularity of the work. Altogether in the time he waited (58 minutes), the Goolden machine cut 175½ feet. The seam was very like the one at Glenclelland colliery with the exception of the top stone. There was a good fake roof, and they brushed the coal 2½ feet with 4 inches of foul coal. The Electric Coal-cutting Corporation were paid 1s. per square yard, equivalent to 1s. 4d. per ton, for cutting. This included the upkeep, attendance and interest on depreciation which, at Glenclelland colliery, were estimated to be 6½d. per ton. The workmen were paid 9d. per ton for breaking out and filling the coal, and the cutting of the pavement and laying of rails, after the machine, cost 7d. per ton, making a total cost of 2s. 8d. per ton. The Coal-cutting Corporation claimed that the increased percentage of round coal would yield a profit, but this was altogether an assumption, and he did not think that at that time they were really able to compare the two systems of working. Could the President state what was the difference in the percentage of round coal between hand-working and machine-working? At the English colliery, referred to, they stated that the profit was about 1s. 6d. per ton, notwithstanding the higher cost of working. He did not think, however, that this profit would be realized. Another question was, how the cost compared now? Wages were now a little less than when the paper was written, and he supposed that when wages were low the machine did not compare so favourably with hand-working as when they were high. He was of opinion from what he had seen of machine coal-cutting, that so long as coal could be worked by hand at less than 3s. per ton, it was hardly worth while trying to cut it by machinery.

The PRESIDENT said that there was a greater difference than Mr. Hogg seemed to think between machine and hand coal-cutting. He thought that the charge for machine-cutting in the case named was very high, and could not understand how it was made up. With reference to the difference in the percentage of round coal, he could not answer absolutely. They had only one machine working at Glenclelland colliery, and worked more coal by hand than by machinery, and they had never made any separate test to ascertain the increased percentage of round coal. They, however, knew that the percentage of dross over the whole workings was considerably decreased after they began the use of the machine, and not only was it decreased, but they got much rounder coal. With reference to the present cost, he could not give it, as the machine was not at work. At the time he read the paper, he mentioned that they were going to turn it to a wall with roads going to the rise. When

they had the holing ready for the machine and started it, they had some water going along the face which made the holing soft: this did not suit the machine so well as the workmen, and they reverted to hand labour. They had another wall prepared, but they came on troubles, and considered it inadvisable to start the machine in it. The machine could not be worked satisfactorily in a faulted field. Mr. Hogg had given it as his opinion that where the cost of hand labour was less than 3s. per ton there would not be a saving by using the coal-cutting machine. He thought that was a matter of circumstance, and depended upon how the cost was made up. He was satisfied, from his own experience, that there were many coal-seams of moderate thickness in which great savings could be effected by adopting coal-cutting machinery.

Mr. ROBERT MARTIN (Niddrie) said that in a 3 feet coal-seam, the miners filled the coal for 1s. 1d., and the machine-cutting cost 5d. per ton, although they allowed a little extra for pipes and other charges. The total cost was considerably under 2s. per ton, and he did not think that miners would have done the same work for a much higher cost. However, unless the coal-field was clean and free from faults, it was not advisable to attempt to work it with coal-cutting machines.

Mr. JAMES MALCOLM (Arniston) said that he would not advise the use of a coal-cutting machine, where the workings were damp or wet.

The PRESIDENT said that at Glenclelland colliery, the holing was made in the daugh, and there could not be the same advantage in the use of coal-cutting machinery as when the holing is in the coal. The coal came down in a block, and he thought that with almost any coal, at least if it was of a soft nature, the percentage of dross would vary from 20 to 25 per cent. The dross was about 30 per cent. with hand labour, and probably it was not more than 25 per cent. where the coal-cutting machine was at work.

Mr. A. M. GRANT (Kilmarnock) asked, with regard to holing in the coal and daugh, whether it was not the fact that when holing in the coal with most coal-cutting machines they got more coal and made less dross?

The PRESIDENT said that that was so.

Mr GRANT—So that the cost is about the same?

The PRESIDENT said that where holing in the coal they saved more in percentage of dross than where holing in the daugh.

Mr. GRANT said that they were cutting more superficial feet per hour or per shift while holing in the coal than when holing in the soft or hard daugh.

The PRESIDENT said that the machine certainly cut a greater area when cutting in coal than in daugh, provided the machine was suited for its work.

Mr. GRANT asked whether the engine, which was 18 inches in diameter and 3½ feet stroke, would drive more than one coal-cutting machine?

The PRESIDENT said that the engine and dynamo were designed to drive 3, and would probably drive more, possibly 5 machines, as the power used was less than estimated.

Mr. WADDELL (Glasgow) asked the President whether he considered electricity or compressed air was the best motive power?

The PRESIDENT said that the principal objection to the use of electricity was that they could not work it satisfactorily in a damp working, but where there was a dry working, he was of opinion that electricity was the best motive power, and it had several advantages over the use of compressed air.

Mr. GRANT said that the engine would afford 7 horse-power for each machine.

The PRESIDENT said that each motor and coal-cutter required about 5½ horse-power according to the tests.

A vote of thanks was given to the President for his exceedingly interesting and valuable paper, and the discussion was closed

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The SECRETARY, authorized by the Council, gave notice of motion for the adoption of bye-law 8B of The Federated Institution of Mining Engineers, and alteration of certain of the rules to accord therewith.

The meeting was then closed.

THE MINING INSTITUTE OF SCOTLAND.

ANNUAL EXCURSION,

SEPTEMBER 5TH, 1895.

The annual excursion, which was attended by 120 members, took place to collieries in Fifeshire.

The following is a description of the surface-arrangements of the collieries visited :—

FIFE COAL COMPANY LIMITED.—THE AITKEN PIT, KELTY.

The Aitken pit is situated within 300 yards of Kelty railway station, and 3,300 feet north-east from the Lindsay pit. Operations were commenced in March, 1893, but the actual sinking of the shaft did not commence till February, 1894. It has now reached the depth of 852 feet, and sinking is suspended until the second plunger-set of pumps is put in and started. In sinking, 300 gallons of water per minute were encountered at 138 feet, 30 gallons at 270 feet, and 20 gallons at 420 feet, where a lodgment was driven, and a 30 inches plunger-pump placed to force the water to the surface. Other 200 gallons per minute is given off at a depth of 600 feet. Below that point, very little water has been got, and it has been dealt with by means of kettle and barrel ; but, since sinking has been stopped, a small steam-pump has been put in to force this water to the bucket-lift at a depth of 600 feet, when much water was given off. Common bucket-pumps, actuated by bell-cranks, have been put in to deal with it.

At a depth of 264 feet, whinstone was found 126 feet thick, and at 480 feet a bed 21 feet thick. Most of it was very hard, and rock-drills driven by compressed-air were supplied for it, and have been used in sinking where available.

The shaft is expected to reach the Dunfermline splint seam at 1,200 feet. It is 27 feet by 11 feet, and is divided into two winding and one pumping space. The cages are intended to hold 4 hutches containing 10 cwts. of coal each, on one deck. The temporary winding-engines have 2

cylinders each 18 inches in diameter by 4½ feet stroke, and a drum 10 feet in diameter. They have been placed on a stone-seat, as it is intended to use them for haulage purposes afterwards. To facilitate the winding in the shaft, guide-ropes fitted with a rider have been put in. The permanent winding-engines have 2 cylinders each 28 inches in diameter by 5 feet stroke, double-beat-valves, and automatic cut-off and exhaust-valves. The drums are 16 feet and 11 feet in diameter, as it is intended to wind from depths of 1,200 and 840 feet respectively.

The temporary pumping-engine has a single horizontal cylinder, 24 inches in diameter by 5 feet stroke, geared 4 to 1, connected to bell-cranks having 5 feet stroke. The bucket-pumps have been 20 inches, 17 inches, and 10 inches in diameter. The permanent pumping-engine is of the balance-beam type, vertical compound and condensing, the high-pressure cylinder is 57 inches in diameter by 9 feet 6¾ inches stroke, and the low-pressure cylinder, 84 inches in diameter by 13 feet stroke; the balance-beam weighs 75 tons; the rods will weigh about 180 tons, and the balance-weight 110 tons. The engine steams both up and down stroke, the expansion being about 3½ to 1. The first plunger is 30 inches in diameter by 13 feet stroke, and forces the water for a height of 420 feet; the pipes, are 24 inches in diameter, having three sets of clacks; the rods are double, 18 inches square at the top, and 15 inches square at the first plunger. The second set is similar to the first, except that the rods taper from 15 inches to 13 inches square. This engine is expected to pump the water of the whole colliery, amounting to about 1,300 gallons per minute in summer, and a little more in winter. Besides this engine, a steam-pump has been fitted into the shaft at a depth of 180 feet, capable of taking the surface-water.

The crab-winch engine has two horizontal cylinders, 8 inches in diameter by 16 inches stroke, and is capable of lifting 40 tons. The rope is 7 inches in circumference. Besides the permanent crab-engine, a temporary one was fitted up to work the service-pumps, capable of lifting about 16 tons. In addition, a 2 tons steam jib-crane having a jib 50 feet long, stands close to the pit to lift pipes and rods, etc.

The winding and crab-frames are of steel, the winding-frame being 60 feet, and the crab-frame 50 feet high. They are constructed for convenience in placing guide-ropes, wheels, and lifting-tackle during sinking, and for detaching-hooks afterwards.

The shaft has been ventilated by a Schiele fan, 3 feet in diameter; but a connexion with a mine at a depth of 720 feet from the Lindsay pit provides ample ventilation at present.

There are five Lancashire boilers in position, 30 feet long by 8 feet in diameter, working at 75 lbs., but the pressure will be raised to 100 lbs. per square inch after the sinking is finished. A Locock economizer of 256 tubes has just been fitted up, and will be connected shortly. The boilers are fed by a Tangye duplex pump, 6 inches in diameter. The chimney is 165 feet high, and 9 feet in inside diameter.

The workshops consist of a smithy having two fires and steam-hammer; a joiner's shop and store; an engineer's shop with engine, vertical boring-machine, turning-lathe, circular saw, etc.

The engine-houses and shops are lighted by means of incandescent electric-lamps, and the pithead by 2 arc-lights of 2,000 candlepower each. The dynamo is capable of giving an output of 120 ampères at 100 volts, and is driven by a vertical compound engine of 35 horse-power.

The air-compressor has steam and air-cylinders 14 inches in diameter by 2 feet stroke.

COWDENBEATH COAL COMPANY, LIMITED.
LUMPHINNANS COLLIERY.

The No. 1 pit is 1,098 feet deep to the Dunfermline splint coal-seam. The seams of coal worked are:—The Dunfermline splint, 4½ feet thick; about 90 feet above this is the five feet seam, 5 feet thick; about other 72 feet up is the mynheer seam, 4 feet thick; and, at a depth of 648 feet from the surface, is the Lochgelly splint and parrot coal, 11 feet thick. All these seams are worked by longwall. There are several other workable seams of coal and ironstone passed through in the shaft, but they are not at present being worked.

There are six Lancashire boilers, 30 feet long by 7 feet, worked at 100 lbs. per square inch, fired with dust-coal and fitted with Meldrum & Granger forced-draught furnaces.

The pumping-engine is double-acting, with 36 inches and 54 inches cylinders by 13 feet stroke in the latter, from which the pump-rods are attached, working two plunger-lifts 21 inches and two plunger-lifts 16 inches in diameter, and a short bucket-lift, 16 inches in diameter.

The winding-engines have two horizontal cylinders, 26 inches by 5 feet stroke, with a parallel drum 15 feet in diameter. Two tubs (on a double-deck cage) are wound containing together on an average 20 cwts. of coal. No shuts are used at any of the pits belonging to the company.

There are four tipplers emptying the coal-tubs into hoppers, from which the coals are carried by distributing bands to the bar-screens, through the bars of which the small or dross-coal passes to a billy-fair-play and on to a cross-band which conveys it to the dross-hole. The large coal passes over the bars to travelling-belts moving at double the speed of the distributing-bands, so as to spread the coals on the table and facilitate picking. These belts are fitted with ends to prevent breakage, and the coals are again passed over bar-screens, the dross being conveyed by cross-belts from each of the four screens to one main-belt which delivers it on the main dross-belt going to the dross-hole. These screens extend over six lines of railways, which are spanned without any intervening posts or supports.

From the dross-hole, the small coal is elevated and passed through a revolving riddle, separating it into dust or duff, single, double, treble, and jumbo nut coal, which are picked on tables. The treble table has lately been altered to bars, or what is termed a German-band. The double-nut table is shortly to be altered to the same, and two conveyors, for carrying away the stones as picked, are to be erected. There are here four lines of railways crossed in one span. The duff coal is carried by a conveyor to the boilers, or to waggons, as required. Two horizontal engines drive the coal and nut-cleaning plant. The staging is supported on railway rails, and from beams on the top all the screens, tables, etc., are suspended, obviating any posts or supports between the lines of railways. The pithead screens, tables, and nut mill are all under corrugated-iron housing.

The works are lighted by incandescent electric lamps.

Some years ago the shaft was deepened 450 feet from the Lochgelly splint and parrot coal-seam, the sinking being carried on continuously while the pit wound coal from that seam at the depth of 648 feet. An old pumping-engine and the pumps to that depth were removed, new pumps put in, and the new double-acting compound engine and boilers erected ; indeed, the whole of the present fitting was made and erected and the old removed without loss of work, advantage being taken of the summer holidays to change the pulley-wheels from the old to the new pithead frame.

No. 1 pit is the downcast, No. 7 pit to the rise being the upcast, where a Guibal fan actuates the air-current.

LOCHGELLY IRON AND COAL COMPANY, LIMITED.
LITTLE RAITH COLLIERY.

The Gordon pit is 19 feet by 10 feet, and is sunk to the Dunfermline splint seam. It is 660 feet deep from the shuts to the bottom. Two cross-cut mines are driven to the five-feet and mynheer seams, and the coals now being worked are :—The Dunfermline splint seam, 5 feet thick ; the five feet seam, 5½ feet thick ; and the mynheer seam, 4¾ feet thick.

The pumping plant consists of a direct-acting engine, with a cylinder 66 inches in diameter by 12 feet stroke. The pumps are in three lifts, namely, two forcing-lifts of 270 feet each, and one bucket-lift of 114 feet. The delivery-pipes for the forcing-lifts are 17 inches and the bucket-lift 20 inches in diameter. The diameter of the bucket is 20 inches and of the delivery-pipes 21 inches.

The winding-engine has two horizontal cylinders 24 inches in diameter by 5 feet stroke, with drums 12 feet in diameter. There is also a crab-winch capable of lifting 30 tons.

The screening arrangements comprise 2 tipplers, 2 shaking-screens, and 2 picking-tables, each 30 feet long. The whole including the tipplers is driven by an engine with a cylinder 9 inches in diameter, by 18 inches stroke.

The engine-houses, pithead, and screens are lighted by electricity. The dynamo is compound-wound, of 100 volts, 30 ampères, and runs at 970 revolutions per minute. It is driven by a Westinghouse automatic engine.

The steam-power for the pumping and winding engines is supplied by four Lancashire boilers, 24 feet long by 7½ feet in diameter.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,
HELD IN THE ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW,
OCTOBER 9TH, 1895.

MR. GEORGE A. MITCHELL, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected:—

FEDERATED MEMBERS—

Mr. JAMES ALLAN, Hillhead, Coylton, Ayr.
Mr. KENNETH M'KENZIE BOWIE, Priory Hill House, Canonbie.
Mr. ARCHD. BOWMAN, Jun., Muiredge Collieries, Buckhaven, N.B.
Mr. WILLIAM FORSYTH, Glenclelland Colliery, Wishaw, N.B.
Mr. R. HOOD HAGGIE, Jun., 270, Great Western Road, Glasgow.
Mr. J. A. LOCHHEAD, Addie's Collieries, Denny, N.B.
Mr. SAMUEL MAVOR, 57, West Nile Street, Glasgow.
Mr. JAMES MORTON, Charlestown Foundry, Dunfermline.
Mr. GEORGE B. NASMYTH, Dundonald, Cardenden, Fife.
Mr. JOHN ROBERT PATERSON, Coal Creek Proprietary Co.. Fink's Buildings, Melbourne, Victoria.
Mr. J. L. PETRIE, Hadfield's Steel Foundry Co., Sheffield.
Mr. JOHN PROVAN, Balgonie Colliery, Thornton, N.B.
Mr. W. M. ROBERTSON, 70, Great Clyde Street, Glasgow.
Mr. HUGH SWAN, Gartcraig Fireclay Works, Shettleston, N.B.
Mr. JOHN TODD, Greenfield Terrace, Irvine.
Mr. ROBERT WEIR, Camp Colliery, Motherwell, N.B.

DISCUSSION ON MR. J. G. BARCLAY'S PAPERS ON "THE BARCLAY CROWN-VALVE EXHAUST-GEAR"* AND ON "AN OVERHANGING BEAM PUMPING-ENGINE."†

Mr. GRANT repeated, what he had previously remarked, that there was nothing new in the Barclay gearing. He had the same type of engine working without back pressure.

The PRESIDENT moved that a vote of thanks be accorded to Mr. Barclay for his papers.

* *Trans. Fed. Inst.*, vol. viii., page 396; and vol. ix., pages 142 and 468.

† *Ibid.*, vol. viii., page 397; and vol. ix., pages 142 and 468.

DISCUSSION UPON MR. ALLAN STIRLING'S PAPER ON "WATER-TUBE BOILERS."*

Mr. STIRLING, replying to the former discussion, said that Mr. Rowan's historical references dealt with boilers that had never passed beyond the experimental stage. Mr. Pell, referred to by Mr. Rowan, was superintendent of the Stirling Boiler Company of America, and was appointed by Mr. Stirling himself. The principal Stirling boiler patent was dated July 26th, 1892, more than a year before the date of the Pell patent. Mr. Pell's arrangement added another mud-drum to the Stirling boiler, and could not be built without infringing the Stirling patent. The tubes below the water-line were clearly shown in Fig. 1†. There had never been any difficulty in dealing with the tube-plates. In one instance at the Etna Steel-works, Ohio, a Stirling boiler had been carelessly allowed to become dry, while the firing was continued until the tubes and even the firebricks were melted, but the tube-plates were not injured, and with new tubes it is still working. As to the fixing of tubes when repairing, the difficulty was more apparent than real, but in deference to the criticisms of some engineers to whom the water-tube system was new, he had built several boilers in this country with the spaces between the tubes greater than the diameter of the tubes, so that an inner tube could be easily passed out; but he had never had occasion to replace inner tubes in a Stirling boiler. The Motherwell boiler‡ had been working night and day for over six months. The water used was of the worst character, the scale yielding on analysis 48 per cent. of sulphate of lime. It was found, a short time after this boiler had been started, that of the 114 tubes leading from the feed-drum to the mud-drum 12 were being choked up, the water going to the mud-drum by these 12 instead of distributing itself over the whole 114 tubes. By curtailing the inlet of these 114 tubes, by means of a plug in each, the difficulty had been overcome. A scale like a fine enamel was formed inside the tubes by the bad water, but there was sufficient movement in the tubes consequent on the expansion and contraction by the furnace-heat to crack the enamel, which found its way to the mud-drum. This boiler was evaporating 11,400 pounds of water per hour.

* *Trans. Fed. Inst.*, vol. ix., pages 2 and 461.
† *Ibid.*, vol. ix., page 3. ‡ *Ibid.*, vol. ix., page 7.

The PRESIDENT asked how long it was since the first Stirling boiler was in operation, and whether any boiler-composition had been used in the Motherwell boiler to get rid of the scale?

Mr. STIRLING said that a number of Stirling boilers had been working for six years. The Carnegie Steel Company, Pittsburg, have had 1,200 horse-power of Stirling boilers in constant use, double shift, for four years; the boilers had given entire satisfaction, were economical of fuel, rapid steamers, easily cleaned, had cost in repairs only £3, and had frequently run 80 per cent. beyond their rating. The Motherwell boiler was treated with soda in the same proportion as the other boilers in the works. He had to thank Mr. Munro and Mr. Dixon for their appreciation of the function of the back group of tubes as a fuel-economizer and feed-water purifier, this being one of the main features of the boiler. He appended tests showing the fuel consumed and steam produced :—

	Belle City Street Railway, Racine, Wisconsin.	Mount Lookout Coal Company, Wyoming, Pennsylvania.	B. F. Goodrich Company, Akron, Ohio.
Rating	200 h.-p.	450 h.-p.	300 h.-p.
Duration of test	8 hours	6 hours	8 hours
Temperature of feed-water ...	168·0° Fahr.	60·0° Fahr.	70·9° Fahr.
Evaporation of water per lb. of coal from and at 212 degs. Fahr.	11·44 lbs.	9·79 lbs.	9·26 lbs.
Evaporation of water per lb. of combustible from and at 212 degs. Fahr.	12·10 lbs.	12·49 lbs.	11·26 lbs.
Coal consumed per square foot of grate per hour...	13·32 lbs.	15·20 lbs.	17·63 lbs.
Draught	0·28 inch	0·23 inch	0·35 inch
Moisture in steam	0·91 per cent.	—	—
Temperature of escaping gases ...	480° Fahr.	464° Fahr.	457° Fahr.
Power developed above rating ...	15·0 per cent.	2·1 per cent.	22·6 per cent.
Kind of fuel used...	Bituminous lump	Anthracite dross	Bituminous dross
Engineer	D. P. Jones	P. Hausen	P. Hausen

The PRESIDENT moved a vote of thanks to Mr. Stirling for his paper, which he said had been an exceedingly interesting one.

Mr. R. FISHER read the following "Notes on Mining in Portugal."

NOTES ON MINING IN PORTUGAL.

By ROBERT FISHER.

Portugal extends for a length of 350 miles between 36 degs. 59 mins. and 42 degs. 8 mins. north latitude, and varies in width from 70 to 140 miles between 6 degs. 10 mins. and 9 degs. 31 mins. west longitude. Spain bounds it on the north and east, and the Atlantic Ocean on the west and south.

The Portuguese are a mixed race: Galician blood predominates in the north, Jewish and Arabic are strongly present in the centre, and African in the south.

The close proximity of Portugal to the ocean tempers its climate. The inequalities of the surface, which is exceedingly undulating, produce, however, diversities of climate: thus snow falls abundantly on the mountains in the northern provinces, but it is never seen in the southern lowlands.

The roads of the country are well kept, and being constructed above the ground-level, good drainage is facilitated. There are few hedges, the roads being fringed with vines and olive-trees.

Railways have been constructed to the extent of 1,400 miles, and afford an international connexion *via* Madrid. The inland transport system is too primitive for the requirements of a productive country. Bullock-carts are principally used: these carts, including the wheels and axle, being of wood, and no oil is used to lubricate the journals, as the people consider it a bad omen if the noise of the axle ceases.

The available labour in the country districts is chiefly agricultural. Many of the people have land which in the fruit season demands their full time. In these circumstances mining industries cannot rely on local labour all the year round, and this is a serious hindrance to the proper working of such concerns.

Very little has been done in Portugal in connexion with coal-mining, not because the country is destitute of coal, but largely on account of the protective policy of the Government, which imposes heavy duties all round, thereby crippling industry and discouraging enterprise. The development of coal-mining has been an important factor in the commercial prosperity of modern nations, and judging from the results

of superficial observations there is little doubt that a systematic and thorough exploration of Portugal would lead to the opening of coal and other mines, to the material benefit of its trade and commerce.

In Great Britain scarcity of coal is only experienced during protracted strikes, in consequence of which the price is raised, and industries dependent on coal are made to suffer. Portugal is in a similar position day by day. While nature has provided abundantly in many ways, the almost idle railway system of that country tells a tale of undeveloped resources and little trade.

There are three distinct coal-deposits in Portugal. In the north, near Oporto, anthracite coal of good quality occurs, but it is often so mixed with shale as to render the working difficult. The principal mines are: St. Pedro da Cora, Passal de Baioco, Covello, and Midors Pegas. The large coal extracted from these mines is used in Oporto in cooking-ranges and stoves, and the small coal is made into briquettes for the same purpose.

Near Busaco, at Santa Catherina, there are seams of a semi-bituminous coal, but they are not now being worked.

Near the town of Batalha, which is situated 60 miles north of Lisbon and 12 miles south of the Oporto and Lisbon railway at Leiria, there is a coal-field extending to 1,200 acres, where the outcrops of several seams of coal have been located, and a few drifts made to prove them towards the dip.

Two adit-levels, about a mile apart, have been driven into the breast of a range of hills several hundred feet high. No. 1 mine, near Batalha, cross-cutting to the dip has intersected four coal-seams (Figs. 1 and 2, Plate III.). The first seam lies at an inclination of 49 degs. towards the east, whilst the others are inclined at from 25 degs. to 30 degs. towards the west. The first coal-seam, 6 inches in thickness, of good quality, and having hanging- and foot-walls of hard blue clay, does not appear to form one of a series of stratified beds overlain unconformably by the other beds, but strikes across the strata. Possibly it may be in the line of a dip fault. The other seams have the following sections:—

No. 1 Coal-seam.	Ft.	In.	No. 2 Coal-seam.	Ft.	In.	No. 3 Coal-seam.	Ft.	In.
Marl roof.			Shale roof.					
Coal ..	0	6	Coal ...	1	4	Coal ...	1	0
Shale ...	1	8	Marl ...	0	6	Shale ...	1	0
Coal ...	1	4	Coal ...	0	6	Coal ...	0	6
Shale ...	1	0	Clay ...	0	6	Fireclay pavement.		
Coal ...	0	6	Coal ...	0	2			
Fireclay pavement.			Fireclay pavement.					

The coal in these seams has the appearance of lignite rather than coal of the Carboniferous measures. The proportion of sulphur and ash is high, and altogether the coal is of little commercial value. Galleries have been driven for a short distance in these seams where the mines intersect them, and there are indications of improvement in thickness and quality towards the dip. No. 2 mine at Alcanada intersects No. 2 seam, into which a dook or dip drift has been driven for a distance of about 90 feet. Another adit mine is being driven at a lower level to intersect the three coal-seams and clear the dook of water. (Figs. 3 and 4, Plate III.) In section, inclination and quality these seams are similar to those at Batalha. The small output of the Batalha mines was, within the past year, sold at 1,000 reis per cubic metre when the rate of exchange was 5,660 reis per £1.

The coal was riddled at the entrance to the mine and the dross carried in baskets on the heads of women to a hand-power washing-machine worked by a woman. (Fig. 5, Plate III.) Women were paid from 5d. to 6d. per day. The water was directed by means of a dam and mill-race, part of the latter being steep. At this point, a woman shovelled the small coal into the current, which carried it into the machine; the washed dross was discharged over the mesh into a basket, which, when full, was emptied into the heap. The dirt was similarly treated; a small shutter fixed at the top of the shoot prevented it from getting out—until discharged when almost filled up to the level of the washed dross.

The Leiria district is fairly flat, and very fertile. Vines, olives, and all kinds of fruit are grown on a large scale. The valley extends inland to Porto de Moz, where the Mountain Limestone rises to the height of several hundred feet. There is abundance of pine timber in the district suitable for mining purposes. Lengths of 50 or 60 feet can be bought at from 1¼d. to 1½d. per lineal foot.

Imported coal is taxed at the rate of 3s. 6d. per ton; whether for the purpose solely of revenue or to protect and promote native industry, it is difficult to say; but in spite of the protective policy of Portugal, the exploration and development of its mineral resources would materially add to its prosperity.

In the vicinity of Porto de Moz, 6 miles south of Batalha, may be seen a coal-seam 3 feet thick, with sandstone roof and hard fireclay pavement, dipping 25 degs. to the north-east towards the Mountain Limestone range of hills, at the base of which the coal-seam is exposed. Underlying it are beds of laminated blue shale with ironstone balls, and limestone beds from 2 to 10 feet thick, as shown below:—

	Feet.	Inches
Sandstone roof.		
Coal	3	0
Clay and ironstone balls	50	0
Limestone	6	0
Shale	7	0
Limestone	2	0
Clays		

The fossils found in connexion with the limestone beds comprise corals, shells, and encrinites; but even with their aid it is difficult to determine whether these beds belong to Oolitic or Carboniferous measures.

The total imports of coal and coke into Portugal in 1892 and 1893 were as follows:—

	1892		1893.	
	Tons.	Value.	Tons.	Value.
Coal...	603,696 ...	£535,527 ...	408,558 ...	£367,030
Coke	13,060 ...	10,628 ...	6,943 ...	8,218

The decrease occurring in 1893 is attributable to the strikes in England, and consequent high prices asked for fuel during that time; and the increase in the manufacture of patent fuel in Portugal, partly from coal-dust imported from England and partly from Portuguese coal. This fuel is taking the place of English coal to some extent at mills and other factories, and coal from the north of Spain is also being introduced.

In the vicinity of Cintra, about 10 miles from Lisbon, the railway passes through extensive beds of fireclay. It is surprising that these beds have not been worked for the manufacture of fireclay goods, for which there is a fair demand in the capital.

The mean annual temperature of Portugal being about 60 degs. Fahr. there is little demand for coal for household purposes. The fuel in common use consists of thin cakes about 3 inches in diameter and 1 inch thick, composed of pitch, sawdust, and small coal. In the forests there is great demand for the smallest branch twigs, for which 2d. to 6d. per tree is paid.

Iron-ore is found distributed generally all over northern Portugal in larger or smaller areas. There is a valuable deposit of magnetic iron-ore at Moncorvo, about 80 miles up the river Douro, but its distance from a seaport renders it valueless until a cheap mode of transit is introduced.

In the Pombal district, 30 miles north from Leiria, there are numerous indications of the industry of the Moors, in the shape of large heaps of slag from iron-smelting. A sample of cinder, evidently made in ancient

times during the production of malleable iron by some elementary direct process of extraction, yielded on analysis 53·3 per cent. of metallic iron and 0·045 per cent. of phosphorus. Samples of iron-ore, near the surface, in the vicinity of Monte Redondi, north of Leiria, contain by analysis, 53 per cent. of metallic iron, a quality very similar to that of the well-known rubio ironstone, but containing a higher percentage of phosphorus.

Silver and lead ores have been worked to a limited extent in Portugal. The principal mines at work are situated at Bracal and Coimbra.

Manganese-ore has been worked to a small extent and exported, at a mine near Anadia.

There are lodes of antimony-ore running from north-west to south-east, about 8 miles from Oporto. The principal mines are: the Gondomar, Tapada, and Vallongo. These have been worked for some years with more or less success. The antimony-ore is found in the quartz-veins which intersect the Silurian schists.

Gold is found occasionally in the quartz-veins, but it is not yet known whether it could be profitably worked. Some samples of the quartz were lately sent to Germany and also to England for trial, and the percentage of gold extracted is believed to be favourable, but the expense of carriage was great, and attention was turned to extracting the gold on the spot. Great secrecy has been maintained on the subject, and the results have not been published.

The import duties on all foreign goods have lately become so high that in many instances two or three times the initial cost has to be paid; and, with the exception of absolute necessities, very little is now being imported from Great Britain.

The industrial tax is also very onerous. The sweeping effects of this impost may be judged from the fact that no less than 539 trades or industries are specially mentioned and taxed, some at fixed rates from 2s. to £200, and others at varying rates.

The want of capital, the lack of native energy and individual enterprise, the comparatively high price of coal, the difficulty and expense of transport in the interior, and the excessive duties levied on machinery and all kinds of products and industries are the most prominent causes which have hitherto impeded the development of the resources of Portugal.

At Lisbon, the shipping facilities are far behind the requirements of the port. New harbour-works were commenced in 1886, but it will be some years before shipping can be loaded and discharged at the quay-wall.

Nature has done so much to enrich Portugal that it is a matter of surprise that its inhabitants should at any time find a difficulty in turning her benefits to substantial profit. On the one hand, there is a soil of extreme fertility, with a temperate climate and practical immunity from pernicious night frosts; on the other, the capital stands at the gates of the east and the west, close to the mouth of one of the finest rivers in the world, which has in former times borne on its surface the wealth of both the East and West Indies.

DISCUSSION ON MR. A. M. GRANT'S "REMARKS ON WINDING-ENGINES."*

Mr. GRANT said that while there might be classes of slide-valves used in winding-engines either with or without steam starting- or reversing-gear, he still adhered to the position taken up by him in his paper, and advised the use of the Cornish valve, although the cost was £250 more, in the case of winding-engines similar to those at Newbattle colliery.

The difficulty with reversing-gear was that, if it gave way at one single pin, control was lost.

The PRESIDENT moved a vote of thanks to Mr. Grant for his paper.

REVISION OF RULES.

Immediately after the General Meeting a Special Meeting of the members was held, for the purpose of considering the recommendation of the Council to adopt Bye-Law 8B of the Federated Institution of Mining Engineers and alterations of the Rules to accord therewith, of which notice had been given at last General Meeting.

The SECRETARY, on behalf of the Council, submitted a copy of the Rules as altered, with a few verbal additions, and moved their adoption, and that they should take effect from January 1st, 1896. An amendment for delay was proposed, but the motion was carried by a large majority.

The meeting was then closed.

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* *Trans. Fed. Inst.*, vol. viii., page, 390; and vol. ix., pages 141 and 466.

To illustrate Mr R. Fisher's "Notes on Mining in Portugal."

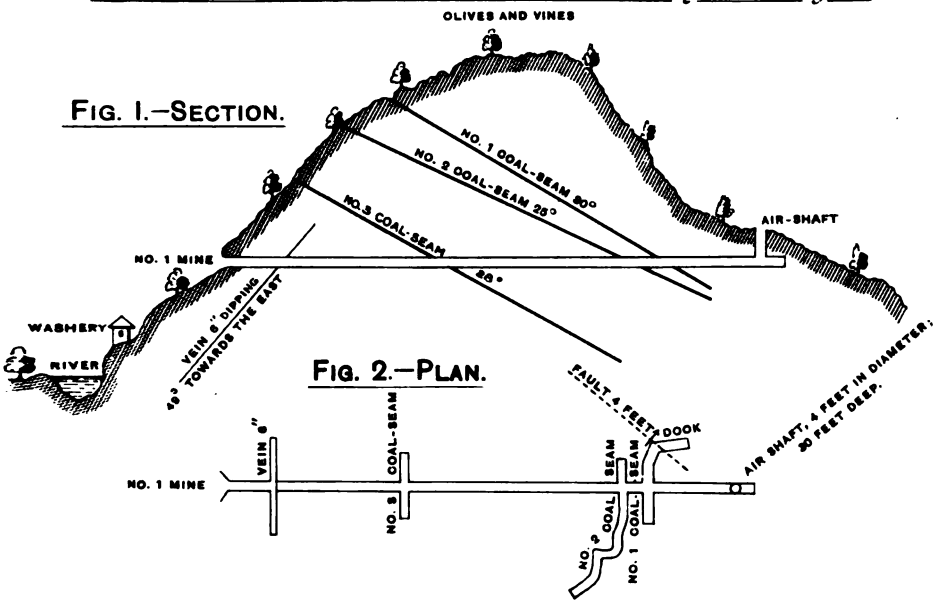

FIG. 1.—SECTION.

FIG. 2.—PLAN.

Scale 350 Feet to 1 Inch.

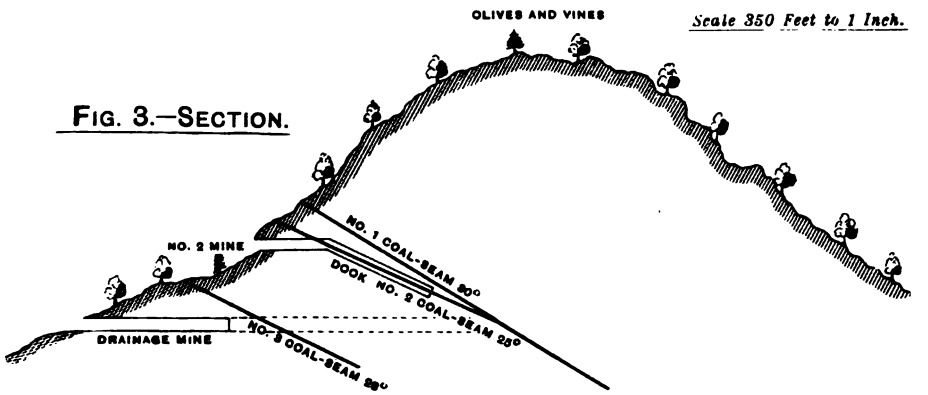

FIG. 3.—SECTION.

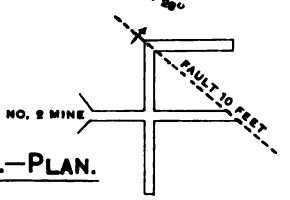

FIG. 4.—PLAN.

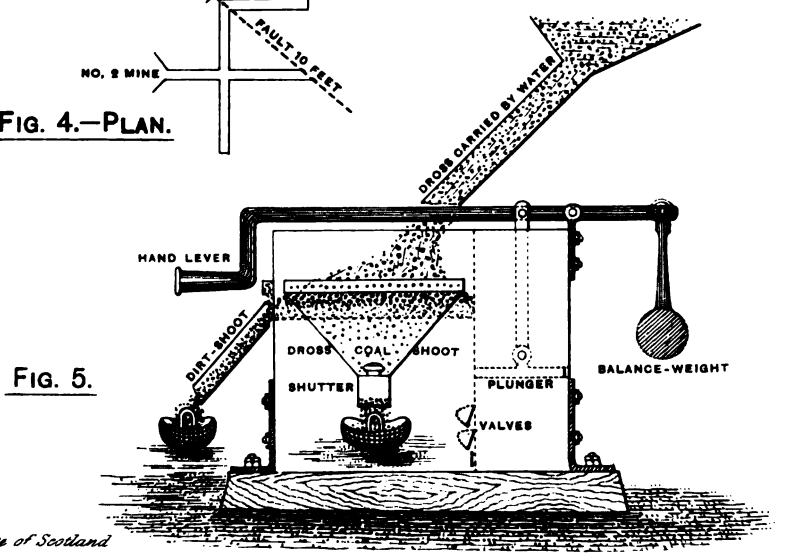

FIG. 5.

And.r Reid & Compy Ltd. Newcastle on Tyne

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

ANNUAL GENERAL MEETING,
HELD IN THE COURT HOUSE, WARWICK, JULY 13TH, 1895.

MR. WILLIAM SPENCER, RETIRING PRESIDENT, IN THE CHAIR.

Mr. J. W. BARLOW and Mr. I. H. SAXTON kindly consented to act as scrutineers of the voting papers for the election of Officers for the year 1895-96.

The SECRETARY announced the election of the following gentlemen :—

MEMBERS—

Mr. WILLIAM RALPH BATES, Alfreton Ironworks, Pye Bridge, Alfreton.

Mr. HENRY WRIGHT, Civil and Mining Engineer, Coolgardie, Western Australia.

ASSOCIATE MEMBER—

Mr. WILLIAM DENNIS HODGKINSON, Contractor, Newthorpe, Nottinghamshire.

ASSOCIATE—

Mr. CHARLES JAMES WADSWORTH, Surveyor, Poynton Collieries, Stockport.

REPORT OF THE COUNCIL.

The following is the usual comparative summary of the number of Members and the state of the finances in the past three years, viz. :—

	1892-93.	1893-94.	1894-95.
Honorary Members ...	14	14	14
Life Members	7	10	10
Members	204	220	224
Associate Members ...	7	0	2
Associates	31	64	73
Students	19	28	27
Totals	282	336	350

	£ s. d.	£ s. d.	£ s. d.
Cash Receipts	444 13 11	549 8 6	491 3 6
Cash Payments ...	501 13 9	551 17 1	495 8 11
Bank Balance	51 15 8	54 4 3	58 9 8
Invested Fund	533 6 8	533 6 8	533 6 8
	£481 11 0	£479 2 5	£474 17 0

Arrears considered recoverable at end of	1892-93.	1893-94.	1894-95
	£39 16 0	£28 12 6	£47 13 0

Thirteen new Members (including 1 late Student), 2 Associate Members, 10 Associates, and 3 Students have been elected during the year—total 28 (as against 75 last year).

The total retirements from all causes are 14 (as against 21 last year), viz.:—9 Members, 1 Associate, and 4 Students.

There has been a net increase of 4 Members, 2 Associate Members, 9 Associates; and a decrease of 1 Student. Total net increase, 14.

Two Members have died during the past year, and are further referred to in Memoirs.

The total number on the roll of the Institution as for the period commenced March 26th, 1895, was 350.

The income of the past year was £58 5s. less than in the previous year, but (omitting three Life Memberships) £4 15s. more than in the previous year.

The expenditure was £56 8s. 2d. less than in the previous year, and £4 5s. 5d. in excess of receipts.

The arrear list, with an insignificant exception, now applies only to the past and previous year, and although in excess of the preceding year, there is reason to believe that it will be largely realized.

No payment whatever has been made to The Federated Institution of Mining Engineers in respect of members' unpaid or arrear subscriptions.

The alteration of the rules by which the now current period of about a year and a third, ends on July 31st, 1896, is having one intended effect in supplying the necessary funds to cover the contributions to The Federated Institution of Mining Engineers up to the new date for the termination of future years.

The negotiations with the Town Council of Chesterfield to vary the terms on which rooms in the Stephenson Memorial Hall are now, and may in future be, used by the Institution, are being definitely settled in a formal document.

The annual meeting of The Federated Institution of Mining Engineers was held in September at Newcastle-on-Tyne. The other meetings were in February at Birmingham and June in London.

Local meetings have been held in Chesterfield on July 7th; in Derby, December 1st; in Leicester, January 26th; and in Nottingham, on March 16th. In addition a Joint Excursion Meeting with the Midland Institute of Mining, Civil, and Mechanical Engineers took place on September 27th, at Shireoaks and Welbeck.

The complete list of papers published in the *Transactions* of The Federated Institution of Mining Engineers since the Council's last report includes the following communications to this Institution:—

"Shireoaks Collieries." *Anon.*
"The Use of Expansion-gear as Applied to Colliery Engines." By Maurice Deacon.
"Continuous-current Dynamos and Motors." By Lancelot W. de Grave.
"Banking-out, Screening, and Mechanical Arrangements for Direct Sorting and Packing of Coal." By William Hay.
"An Underground Endless-rope at the Moston Colliery, Manchester." By H. Richardson Hewitt.
"Leicester Sewage-pumping Station at Beaumont Lays." By E. G. Mawbey.
"Presidential Address." By William Spencer.

The annual meeting of The Federated Institution of Mining Engineers is fixed to be held at Stoke-on-Trent on September 18th and 19th. The succeeding meeting will be in the district of the Chesterfield Institution in the following February, and in anticipation of the gathering on that occasion of representatives of mining districts throughout the kingdom the Council have invited Mr. Emerson Bainbridge, who has consented to accept the Presidency of the Chesterfield Institution, and to take an active part in the reception of visitors, for which his important and extensive practice and interest in mining undertakings eminently qualify him.

To Mr. William Spencer, the retiring President, the Council desire to express their appreciation of his attention to the duties of the office.

ABSTRACT OF ACCOUNTS

	INCOME.	£ s. d.	£ s. d.
195	Members	307 2 6	
	One resumed Membership (not in List)	1 11 6	
	Two, late Associates, paid Entrances	1 1 0	
79	Associates and Students	79 0 0	
8	New Members and Entrances	21 0 0	
2	New Associate Members and Entrances	5 5 0	
12	New Associates and Students	12 0 0	
			427 0 0
296			
	Seven Members paid in advance	11 0 6	
	One New Member do. and Entrance ...	2 12 6	
			13 13 0
			440 13 0
	Arrear Subscriptions received, 1891-92	3 3 0	
	Do. do. 1892-93	4 14 6	
	Do. do. 1893-94	9 9 0	
	Do. do. (after being struck out)	1 11 6	
			18 18 0
			459 11 0
	Transactions and Excerpts sold		8 3 9
	Midland Railway Company's Debenture Interest ...		15 9 8
	Bank Interest		1 17 7
	Letting of Council Room		4 10 0
	Subscription paid in error and returned		1 11 6
	Total Receipts ...		491 3 6
	Unpaid Arrears as per Subscription a/c	42 10 0	
	Do. 1893-94 Account £9 6 0		
	Do. 1892-93 Do. 2 0 0		
		11 6 0	
		53 16 0	
	Irrecoverable	6 3 0	
	Net arrears to collect		47 13 0
	Balance as per contra		58 9 8
			£597 6 2

Certificate of £533 6s. 8d. Midland Railway Company's 3 per Cent. Debenture Stock, and Policy of Assurance Alliance Co. for £500, deposited in Bank.

YEAR ENDING 25TH MARCH, 1895.

EXPENDITURE.	£ s. d.	£ s. d.
The Federated Institution of Mining Engineers upon copies of Transactions, supplied at 17s. per Member:—		
Balance of Calls, 1893-94 (Vols. VI. and VII.) ...	70 13 0	
Part of Calls, 1894-95 (Vols. VIII. and IX.) ...	248 4 0	
		318 17 0
Excerpts, Exchanges, etc.		7 6 8
A. Reid & Co., Ld., Printing and Stationery	16 19 11	
Bemrose & Sons, Ld., do. do.	15 13 9	
W. Edmunds, do. do.	0 3 6	
		32 17 2
Auditors		3 3 0
Reporting Proceedings		12 5 0
Fire Insurance		0 12 6
Postages, Parcels, and Telegrams		13 18 11
Travelling and Incidental Expenses		14 5 4
Fees at Meetings, Requisites, and Services		3 4 0
Secretary's Salary, Assistance, and Use of Office		80 0 0
Bankers' Charges		0 17 10
Subscription paid in error, returned		1 11 6
Corporation of Chesterfield—Letting of Rooms		6 10 0
Total Expenditure ...		495 8 11
Receipts for Subscriptions, etc., on Account of 1895-6 ...	164 12 0	
Payments on Account of 1894-5 ... ... £58 9 8		
Do. do. 1895-6 ... ... 27 1 3		
	85 10 11	
Cash in Messrs. Crompton & Evans' Union Bank, Ltd., Chesterfield, June 6th, 1895	79 1 1	
Balance from Last Year		54 4 3
Arrear Subscriptions		47 13 0
		£597 6 2

June 6th, 1895,

Examined and found correct,

JOHN HALL,
JOHNSON PEARSON, } AUDITORS.

DR. THE TREASURER IN ACCOUNT

		£ s. d.	£ s. d.
229	Members, as per List, 1894-5, of whom		
9	are Old Life Members		
220	Members	346 10 0	
	Less 5 paid in advance last year	7 17 6	
			338 12 6
	One resumed Membership (not in List)		1 11 6
229			
	Two, late Associates, paid Entrance		1 1 0
	Seven Members paid in advance, 1895-6	11 0 6	
	One New Member do. and Entrance ...	2 12 6	
	Two New Associate Members do. do. ...	5 5 0	
			18 18 0
93	Associates and Students, as per List 1894-5, of whom		
1	paid last year as Life Member.		
92	... ...	92 0 0	
	Two paid last year in advance	2 0 0	
			90 0 0
8	New Members and Entrances		21 0 0
12	New Associates and Students		12 0 0
341			483 3 0
	Arrears per last Balance Sheet	28 12 6	
	Deduct Irrecoverable, not included in 1895-6	6 3 0	
			22 9 6
			£505 12 6

WITH SUBSCRIPTIONS, 1894-5. CR.

		Unpaid. £ s. d.	Paid. £ s. d.
195	Members		307 2 6
9	Old Life Members		
5	Paid in advance last year		
20	Unpaid	31 10 0	
	One resumed Membership (not in List)		1 11 6
229			
	Two, late Associates, paid Entrance		1 1 0
	Seven Members paid in advance, 1895-6		11 0 6
	One New Member do. and Entrance		2 12 6
	Two New Associate Members do. do.		5 5 0
79	Associates and Students		79 0 0
2	Paid last year in advance		
11	Unpaid	11 0 0	
92			
8	New Members and Entrances		21 0 0
12	New Associates and Students		12 0 0
341		42 10 0	440 13 0
	Arrears per last Balance Sheet	11 6 0	17 6 6
		53 16 0	457 19 6
	Irrecoverable	6 3 0	
	Arrears to collect		47 13 0
			£505 12 6

June 6th, 1895.—Examined and found correct,

JOHN HALL,
JOHNSON PEARSON, } AUDITORS.

The CHAIRMAN moved the adoption of the report which he remarked was satisfactory, there having been a net increase in the membership, and the finances showing signs of improvement.

Mr. R. SMALLMAN (Nuneaton) seconded the motion, which was adopted.

Mr. A. H. STOKES (Derby) read the following paper on the "Photometric value of, and Notes upon, various Illuminants used in Mines":—

PHOTOMETRIC VALUE OF, AND NOTES UPON, VARIOUS ILLUMINANTS USED IN MINES.

By A. H. STOKES, H.M. Inspector of Mines.

Introduction.

The object of the writer in making the experiments recorded in this paper was to determine the relative amount of light obtained from the illuminants used in mines, to define their economical value, to point out certain adjuncts used for increasing their light, and to call attention to defects and dangers which occasionally accompany their use.

Experiments were made to ascertain the light-intensity of safety-lamps and candles, when compared with a standard candle; safety-lamps and candles have also been compared with each other, and their relative light-giving intensities ascertained.

Before describing the experiments, the writer will specify the various details of the arrangements and manipulations, so that the conditions under which the experiments were made can be fully understood.

Photometer.—The photometer at the South Normanton gas-works, erected in accordance with statutory requirements for the purpose of testing the illuminating power of lighting-gas, was used in all of the experiments. This photometer is of the Bunsen type, is erected in a dark room, and consists of a horizontal graduated bar carrying a disc-box and a pointer made to slide thereon. Inside the disc-box is a thin paper diaphragm, which can be moved at right-angles to the plane of the graduated bar. The paper diaphragm was greased on the whole of its surface, except upon the area of a circle 1½ inches in diameter in the centre.

The light to be tested was placed at one end of the graduated bar with the standard light at the opposite end, both at equal distances from the centre of the bar. The centre of the two lights and the centre of the circular area of ungreased paper in the disc-box were placed in line and parallel with the graduated bar. The disc-box was then moved along the bar until the spot on the greased disc was nearly invisible, or both sides were equally illuminated. The pointer on the disc-box then indicated

upon the graduated bar, the relative intensity of the two lights. The principle upon which the photometer depends being that light varies in intensity inversely as the square of the distance from the source of illumination.

Standard of Light.—The light given by a well trimmed modern safety-lamp has frequently been stated to be equal to 0·75 of the light given by a standard sperm candle, but the value of such a light compared with a candle similar to those used in mines does not appear to have been ascertained.

A miner's candle varies in size, from 24 to 16 to the pound, and burns at varying rates; equally, a safety-lamp is not a standard of light, for the construction and the material burnt influence the amount of light. It was therefore necessary that a recognized standard of light should form the basis of comparison.

Standard Candle.—The standard of light used by gas engineers, and which is also the statutory standard of illuminating value, is a sperm candle (6 to the pound), burning at the rate of 120 grains per hour. The consumption of sperm is accelerated or retarded by varying conditions. A delicate balance is used for weighing the candle before and after each experiment, so that the precise quantity of sperm burnt during a given period of time may be correctly ascertained, and the intensity of illumination reduced or increased, as the case may require, to bring the test to the standard of light obtained by burning 120 grains of sperm per hour.

Safety-lamp.—The safety-lamp used was an ordinary miner's safety-lamp. In some of the tests, the lamp had only one gauze and then, theoretically, it was a bonneted Clanny; and in other tests, it had two gauzes, and then assumed the Marsaut type. In some of the tests, the lamp had a clear glass; and in other tests, one-third of the surface of the glass was enamelled white to act as a reflector. The same lamp-top was used in all the experiments, and all of the parts being interchangeable, there was no difficulty in arranging for a number of oil-vessels being filled with oils and otherwise prepared ready for use, the delay which would have otherwise occurred had only one oil-vessel been available was thus avoided. Each oil-vessel was trimmed with 3 inches of dried lamp-wick, inserted in a corrugated wick-burner.

Oil.—The names of the oils, used as illuminants, are stated in the tables of experiments, but the makers' names are, for obvious reasons, omitted.

Many descriptions of oil are sold for use in safety-lamps: some of them being designated by a compound name of a most misleading nature. In some, the name of a seed oil, with a Latin suffix, indicating a vegetable extraction, is used, while as a fact, it is a low-flashing mineral oil. It would be preferable if such oils were known by their maker's name, rather than a name which gives no information whatever concerning their nature and properties, and the user would then be less likely to be misled.

Colza and rape oils are not always of uniform quality, and frequently vary both in price and illuminating-power.

The oils sold by some makers, and especially those described as safety-lamp oils are, in many cases, the maker's own mixture, and their composition is a trade secret.

Petroleum.—Various descriptions of petroleum were tested, but the petroleum used in the experiments, and mixed with vegetable oils, was in nearly all cases "royal daylight." The flashing-point of petroleum varies considerably; it should not have a lower flashing-point than 73 degs. Fahr., but in one description of petroleum the flashing-point was 75 degs. Fahr., while another sample flashed at 58 degs. Fahr.

It should be generally known that there are legal regulations with respect to the sale of petroleum. Such regulations were made for the purpose of preventing accidents to persons who incur risks inseparable from the handling of inflammable liquids, and for this purpose a standard, technically known as the "flashing-point," has been fixed, whereby any mineral oil which gives off an inflammable vapour at a temperature less than 73 degs. Fahr. must be stored under special license. The object is to secure a sufficient margin of safety to protect persons using such oil with ordinary care.

The terms petroleum and paraffin include mineral oils of both high and low flashing-points. It is therefore important that consumers of petroleum, whether it is to be used in open lamps, or for mixture with vegetable oils to form a safety-lamp oil, should know the flashing-point of the mineral oil used. The Royal Commission on Accidents in Mines recommended that petroleum of a lower flashing-point than 80 degs. Fahr. should not be used.

The law provides that a special license must be obtained for storing or using paraffin or petroleum of a lower flashing-point than 73 deg. Fahr., and heavy penalties may be imposed upon persons who neglect to conform to the requirements of the Act. It is important that users of

mineral oil of any description, and under whatever name it may be sold, should make tests to ascertain the flashing-points of the oils they store or use, or they may have the whole of their stock confiscated and heavy penalties imposed, unless they hold a license and have it stored in conformity with the condition under which the license is granted.

The statutory conditions under which mineral oil, or more properly mineral spirit, whose flashing-point is below a certain standard, should be stored or used appear to be little known among a large number of colliery officials, and it is no doubt thought that the ordinary paraffin or petroleum used at collieries has a sufficiently high flashing-point to prevent its being subjected to the provisions of the Petroleum Acts. The term "petroleum," used in the Acts, includes any product of petroleum or bituminous mineral which, when tested in an Abel tester, gives off an inflammable vapour at a temperature of less than 73 degs. Fahr.

The large number of accidents to life and property caused by the use of mineral oils, especially those having a low flashing-point, rendered necessary that the storage and use of oils having a flashing-point below certain standard should be placed under restrictive regulations, so as to protect the community from the risks inseparable from the handling of inflammable liquid, and, as far as possible, prevent accidents.

All such enactments apply to mineral oil, whether kept for private use or for sale, and they therefore should be observed at all mines where petroleum or other mineral oil is used for lighting purposes.

Whilst making the photometric experiments, it was found that some of the petroleums used, when tested in an Abel tester, did flash below the 73 degs. Fahr. standard, and they therefore should have either been rejected by the users, or stored and used according to the provisions of the Petroleum Acts.

There are a number of mineral oils now being used in safety-lamps with a flashing-point under 73 degs. Fahr., and therefore require to be used under the statutory regulations. If such mineral oils are used, except under license granted by the local authority under the Acts, the occupier of the place where it is kept is liable to "a penalty not exceeding £20 a day" for each day it is so kept, and to confiscation of the whole of the quantity stored.

There are various other stringent regulations with heavy penalties attached, but sufficient has been stated to show that wherever petroleum or other mineral oils, which give off an inflammable vapour at a temperature of less than 73 degs. Fahr., are used, there should be equally stringent precautionary measures taken to control its safe use and comply with the statutory regulations.

The regulation flashing-point was previously fixed at 100 degs. Fahr., and appears to have been lowered to meet the demand for a water-white oil, but it is questionable whether water-white oils, if chemically treated, can compete in illuminating-power with the oils finished by distillation. When the temperature of the bottom of a burning lamp is considered, or even the temperature of the atmosphere of some mines, it is doubtful whether any mineral oil or spirit should be allowed to be used in coal-mines of a lower flashing-point than 100 degs. Fahr.

Crude petroleum is a mixture of oils of different degrees of inflammability, and when distilled the lighter oils are given off first and will flash at ordinary pressure and temperature, and the residuum left after distillation forms a heavy viscid oil used for the lubrication of machinery. The oils, or what might be more properly termed spirit, which distil first, are so volatile that their use would be dangerous in ordinary lamps; but the oils which find a place between the volatile inflammable spirit and the heavy viscid oil are suitable for use in safety-lamp oil-mixtures. This wide range of different paraffins renders it expedient to draw a line between (1) volatile inflammable spirit, (2) burning oil, and (3) heavy oil, and to exclude from use as burning oils those which give off vapour at ordinary temperatures, hence it is necessary that a distinction should be made by the imposition of a standard flashing-point, and by this means a margin of safety would be secured sufficient to guard against accidents when the oil is used with ordinary regard to its nature and properties.

Candles.—In the experiments, two descriptions of candles were used, viz., common tallow and wax composite. In the first, the wick consisted of a number of cotton threads, and in the wax composite the wick was prepared and plaited. The cotton wick of tallow candles requires frequent snuffing, if burning in a still atmosphere, but when used in a mine with a good current of ventilation the snuff does not accumulate to any great extent. The tallow candles used were kept snuffed and burning at their brightest. The plaited wick of the composite wax candle burns away without serious deterioration of the light and seldom requires snuffing.

Experiments.

The experiments were made under the following conditions:—Various oil-merchants were applied to for samples of safety-lamp and other oils, and samples were also obtained from various collieries using safety-lamps.

A number of clean oil-vessels were charged with the different oils to be tested, and were trimmed by a colliery lamp-man. Before commencing

the experiments, all the wicks were lighted and allowed to burn until the oil-vessel became warm, so that the oil might be burnt at a temperature as near as possible to what it would be when in use in a mine.

The lamp-top was also warmed before commencing the experiments, so that the conditions might be similar with respect to ingress and egress of the air-feed for the flame.

Immediately before an experiment was made, the wick was snuffed clean, the oil-vessel was screwed into the lamp, and the light adjusted, by two experts in the use of lamps, who sought to obtain the maximum amount of light without smoke.

The safety-lamp, or candle, after having its light adjusted, was taken into the photometer room (dark room), and its photometric power ascertained by three persons, each making a separate test.

In all the experiments, at least three tests were made, and the average of these readings are recorded in the tables. The work of trimming, adjusting, testing, and recording was divided, so that throughout the experiments the same persons devoted their attention to the particular section of the experiments allotted to them. This care was taken so as to ensure, as far as possible, uniformity of conditions and observations.

First Series of Experiments.—Table I. records the results of experiments made to test the photometric value of various oils burning in a safety-lamp of the Marsaut type (fitted with two gauzes, an ordinary clear glass, and flat cotton wick $\frac{7}{16}$ inch wide) as compared with a standard sperm candle burning 120 grains per hour.

The object of the first series of experiments (Table I.) was to ascertain the amount of light given by a well trimmed Marsaut safety-lamp, to notice the effect of two gauzes upon the free burning of the light, and to obtain the comparative photometric value of various oil-flames, when surrounded by a clear lamp-glass.

In only four cases did the light exceed half that of a standard candle, viz., experiments Nos. 18, 19, 22, and 23, and even in these cases the light was practically only half that of a standard candle. In one case (experiment No. 11) the light was not equal to one-quarter of a standard candle.

There appeared to be two causes for such a low illuminating-power: (1) Two gauzes are detrimental to the free ingress of air to feed the flame, and they impede the egress of the products of combustion; (2) The clear glass cylinder round the flame allows the light to radiate in all directions.

TABLE I.—EXPERIMENTS AS TO THE PHOTOMETRIC VALUES OF VARIOUS OILS BURNING IN A MARSAUT SAFETY-LAMP, FITTED WITH 2 GAUZES, AN ORDINARY CLEAR GLASS, AND A FLAT COTTON WICK.

No. of Experiment.	Standard Candle burning 120 grains of Sperm per Hour.	Comparison. Description of Light Tested.	Comparison. Photometric Reading – Minus + Plus.	Comparison. Intensity of Light compared with that of the Standard Candle.	Oil burnt in the Safety-lamp.	Price per Gallon. s.	Price per Gallon. d.	Proportions used.	Price of Mixture per Gallon. s.	Price of Mixture per Gallon. d.	Remarks.
1	Standard candle	Safety-lamp	−2·30	0·43	Safety-lamp oil	1	5				
2	,,	,,	−2·54	0·39	Colzaline ...	0	9				
3	,,	,,	−2·62	0·38	Safety-lamp oil	1	8	...		...	Different makers.
4	,,	,,	−2·75	0·36	,,	1	4	...			
5	,,	,,	−2·23	0·44	Lille colza ...	2	1		1	6½	
					R. d. petroleum*	0	5½				
6	,,	,,	−2·90	0·34	Lille colza ...	2	1		1	8¼	
					R. d. petroleum*	0	5½				
7	,,	,,	−3·26	0·30	English rape ...	1	9		1	4	
					R. d. petroleum*	0	5½				
8	,,	,,	−4·03	0·25	English rape ...	1	9		1	5¼	
					R. d. petroleum*	0	5½				
9	,,	,,	−3·45	0·29	Stettin colza ...	2	1		1	6½	
					R. d. petroleum*	0	5½				
10	,,	,,	−3·70	0·27	Stettin colza ...	2	1		1	8¼	
					R. d. petroleum*	0	5½				
11	,,	,,	−4·44	0·22	English rape ...	1	9		1	4	
					R. d. petroleum*	0	5½				
12	,,	,,	−3·01	0·33	English rape ...	1	9		1	5¼	
					R. d. petroleum*	0	5½				
13	,,	,,	−3·07	0·32	Stettin colza ...	1	11		1	6⅓	
					R. d. petroleum*	0	6				
14	,,	,,	−2·65	0·37	English rape ...	1	11		1	6⅓	
					R. d. petroleum*	0	6				
15	,,	,,	−2·20	0·45	Colzaïne ...	0	9	...		...	Different makers.
16	,,	,,	−2·10	0·47	,,	0	9	...			
17	,,	,,	−3·12	0·32	English rape ...	1	9				
18	,,	,,	−1·98	0·51	Safety-lamp oil	0	8			...	Different makers.
19	,,	,,	−1·85	0·54	,,	1	6	...			
20	,,	,,	−2·24	0·44	Foreign colza ...	1	10				
21	,,	,,	−2·12	0·47	Best colza ...	2	3				
22	,,	,,	−1·91	0·52	Thorneburry oil	0	10	...	...	...	Barton burner.
23	,,	,,	−1·96	0·51	,,	0	10	...	...	...	Ordinary safety-lamp burner.

* Royal daylight petroleum.

The light in no case burnt with that clear and lively intensity when inside the lamp as it did when uncovered.

Second Series of Experiments.—Having found by the first series of experiments (Table I.) that two gauzes and a clear glass surrounding the flame did not either conduce to the free-burning of the light or concentrate the light, the second series was made with the same safety-lamp, but having only one gauze, and a lamp glass having one-third of its internal surface enamelled white so as to form a reflector at the back of the light.

This series of experiments (Table II.) very clearly shows advantage of free ingress of air to the flame, and equally free egress the products of combustion. The experiments also show the value white reflector, and the increased light which may be obtained in a ward direction by using a white background to concentrate and f the light in a given line. In some cases the light was more than do that given by the same oil and wick in the first series of experim (Table I.).

TABLE II.—EXPERIMENTS AS TO THE PHOTOMETRIC VALUES OF VARIOUS IN A MARSAUT SAFETY-LAMP FITTED WITH 1 GAUZE, AND ONE-THIR THE GLASS BEING ENAMELLED WHITE SO AS TO FORM A REFLECTOR AT BACK OF THE LIGHT.

No. of Experiment.	Standard Candle burning 120 grains of Sperm per Hour.	Comparison. Description of Light Tested.	Comparison. Photometric Reading – Minus + Plus.	Comparison. Intensity of Light compared with that of the Standard Candle.	Oil burnt in the Safety-lamp.	Price per Gallon. s.	Price per Gallon. d.	Proportions used.	Price of Mixture per Gallon. s.	Price of Mixture per Gallon. d.	Remarks.
24	Standard candle.	Safety-lamp	−1·14	0·87	Safety-lamp oil...	1	5	...	...		Same oil as u No. 1 Ex. Average of 9
25	,,	,,	−1·03	0·96	Colzaline ...	0	9	...	...		Same oil as u No. 2 Ex. Average of 6
26	,,	,,	−1·29	0·77	Lille Colza ... / R.d. petroleum*	2 / 0	1 / 5½	¾ / ¼	1	6½	Same oil as u No. 5 Ex. Average of 6
27	,,	,,	−1·37	0·72	Colzaïne... ...	0	9	...	...		Same oil as u No. 15 Ex.
28	,,	,,	+1·02	1·02	,,	0	9	...	...		Same oil as u No. 16 Ex. Average of 6
29	,,	,,	−1·16	0·85	Safety-lamp oil...	0	8	..	...		Same oil as u No. 18 Ex.
30	,,	,,	−1·35	0·74	,,	1	6	...	...		Same oil as u No. 19 Ex. Average of 6
31	,,	,,	−1·30	0·77	Foreign colza ...	1	10	...	...		Same oil as u No. 20 Ex.
32	,,	,,	−1·11	0·90	Thorneburry oil	0	10	...	...		Ordinary safe lamp burne
33	,,	,,	−1·23	0·81	,,	0	10	...	...		Barton burne
34	,,	,,	+1·03	1·03	Safety-lamp oil...	1	4	...	...		Same oil as u No. 4 Ex.
35	,,	,,	+1·32	1·32	,,	1	10				
36	,,	,,	−1·18	0·85	,,	1	6	...	...		Same oil as u No. 19 Ex.
37	,,	,,	+1·07	1·07	Best colza ...	1	7				

* Royal daylight petroleum.

It will be seen by the table of experiments that in four cases Nos. 34, 35, and 37, the light was greater than that of a standard candle, that in only two cases, Nos. 27 and 30, did it fall below 0·75 of

standard candle. The increase of light, however, was not uniform. In experiment 34 the light was 0·67 more than in No. 4 experiment (Table I.), and in No. 30 it was only 0·20 more than in No. 19 experiment, the average increase of light being 0·39.

TABLE III.—EXPERIMENTS AS TO THE PHOTOMETRIC VALUES OF TALLOW AND WAX COMPOSITE CANDLES OF VARIOUS SIZES.

[illegible]	Standard Candle burning 120 grains of Sperm per Hour.	Comparison.			Number of Candles per Pound.	Price per Pound.	Remarks.
		Description of Light Tested.	Photometric Reading. – Minus. + Plus.	Intensity of Light compared with that of the Standard Candle.			
[illegible] 8	Standard candle	Candle, tallow	+ 1·12	1·12	24	d. 4	
[illegible] 9	,,	,,	+ 1·41	1·41	20	,,	Generally used by miners.
[illegible] 0	,,	,,	+ 1·70	1·70	18	,,	
[illegible] 1	,,	,,	+ 2·11	2·11	16	,,	
[illegible] 2	,,	,,	+ 1·92	1·92	14	,,	Seldom used by miners.
[illegible] 3	,,	,,	+ 1·71	1·71	12	,,	
[illegible] 4	,,	,,	+ 1·53	1·53	18	,,	Candle used by Blackwell colliery miners.
[illegible] 5	,,	Wax composite	+ 1·56	1·56	20	,,	
[illegible] 6	,,	,,	+ 1·32	1·32	18	,,	Generally used by miners.
[illegible] 7	,,	,,	+ 1·37	1·37	12	,,	
[illegible] 8	,,	,,	+ 1·50	1·50	10	,,	Seldom used by miners.

Third Series of Experiments.—The experiments up to this point had been made with the standard sperm candle as a basis of comparison, such tests being necessary, because the standard candle was the recognized measure of light and one of uniform intensity, whereas the miner's candle is an ever varying quantity and a most unstable and fluctuating illuminant, influenced by size, quality, wick, stagnant or brisk ventilation, and inclination of position.

Formerly, candles with cotton wicks, from 20 to 24 to the pound, were universally used in mines, but since wax composite candles with plaited wicks have been introduced, they have gradually been adopted, and are now largely used by miners. Although, generally, they do not give the same amount of light, size for size, as a clean snuffed tallow candle, they are cleaner-burning and more uniform in their illuminating-power because of the absence of snuff.

In the third series of experiments, the candles were burned a short time before being tested, so that they might be at their full burning-consumption, and in all cases were clean-snuffed and made to give their highest intensity of light.

It will be seen that in all the experiments (Table III.) the ta[illegible] and wax composite candles gave a greater amount of light than [illegible] standard sperm candle. In one case, No. 41 experiment, even m[illegible] than double the amount. It will also be noticed from Table III. tha[illegible] was not always the thickest candle that gave the greatest amount of lig[illegible] much depended upon the grains of tallow or wax composite burnt p[illegible] hour, and also upon the quantity and quality of the wick.

Fourth Series of Experiments.—The experiments in the first, second[illegible] and third series were made with a standard and uniform base, but thos[illegible] recorded in Table IV. are of more practical value, as they show the[illegible] difference between a safety-lamp and an ordinary miner's candle.

The comparison between the experiments in the first and second series of experiments had shown the influence of a single gauze, and the white reflector, and one of the best lamps, as regards light, was selected for comparison with candles.

The experiments recorded in Table IV. were made with a Marsaut lamp, with one gauze (and glass, one-third of whose surface was enamelled white so as to form a reflector at the back of the light) as compared with tallow and wax composite candles.

In two experiments, Nos. 49 and 50, the safety-lamp gave more light than the tallow candle. In all cases the light from a tallow candle soon decreased in intensity after being snuffed. The snuffing of the end of the plaited wick of the wax candles increased the light for a short time, but the tallow candles varied so much that a test was made to see the effect of snuffing and continued burning: this will be seen by reference to experiments Nos. 70 and 71, where a candle of the size of 18 to the pound, when cleanly snuffed, was equal to 0·98, or practically the same as a safety-lamp; and after burning 30 minutes—both the safety-lamp and the candle remaining untouched—in a still atmosphere, the illuminating-power of the candle had decreased to 0·30 of the light of the safety-lamp, or a decrease of 70 per cent. of light in 30 minutes' burning, due to snuff.

It was thought that a period of 30 minutes without snuffing was too long, and that the decreased light would be obtained in a much shorter time, therefore another test was made, with another candle of the same number per pound, and the results are shown by experiments Nos. 72 and 73. The candle immediately after being snuffed gave 1·66 the light of the safety-lamp, but 10 minutes afterwards, both safety-lamp and candle remaining untouched, the candle light had fallen to 1·04, or a loss of 37 per cent. of intensity of light during 10 minutes' burning.

TABLE IV.—EXPERIMENTS AS TO THE INTENSITY OF THE LIGHT OF WAX COMPOSITE CANDLES COMPARED WITH THAT OF A MARSAUT SAFETY-LAMP, FITTED WITH 1 GAUZE, AND ONE-THIRD OF THE GLASS BEING ENAMELLED WHITE, SO AS TO FORM A REFLECTOR AT THE BACK OF THE LIGHT.

No. of Experiment.	Safety-lamp, with One Gauze and Enamelled White Glass Reflector.	Comparison.			Number of Candles per Pound.	Remarks.
		Description of Light Tested.	Photometric Reading. – Minus. + Plus.	Intensity of light of Candle compared with that of the Safety-lamp.		
49	Safety-lamp.	Candle, tallow.	– 1·17	0·85	24	Safety-lamp, burning colza oil mixed with one-third of petroleum, maximum light without smoking.
50	,,	,,	– 1·06	0·94	20	
51	,,	,,	+ 1·36	1·36	12	
52	,,	,,	+ 1·20	1·20	18	Candle used by Blackwell colliery miners.
53	,,	Wax composite.	+ 1·11	1·11	18	
54	,,	,,	+ 1·27	1·27	12	
55	Safety-lamp, same as used in No. 28 Experiment.	Candle, tallow.	+ 1·22	1·22	18	Candle used by Blackwell colliery miners.
56	,,	,,	+ 1·13	1·13	24	
57	,,	,,	+ 1·32	1·32	20	Average of six tests.
58	,,	,,	+ 1·90	1·90	12	
59	,,	Wax composite.	+ 1·11	1·11	18	Average of six tests.
60	,,	,,	+ 1·34	1·34	12	Average of six tests.
61	Safety-lamp, burning best colza oil.	Candle, tallow.	+ 1·05	1·05	24	Same oil as used in No. 21 Experiment, with single gauze and enamelled white glass.
62	,,	,,	+ 1·07	1·07	20	
63	,,	,,	+ 1·43	1·43	12	
64	,,	,,	+ 1·23	1·23	18	Candle used by Blackwell colliery miners.
65	,,	Wax composite.	+ 1·39	1·39	18	
66	,,	,,	+ 1·44	1·44	12	
67	Safety-lamp, same as used in No. 28 Experiment.	,,	+ 1·27	1·27	20	
68	,,	Candle, tallow.	+ 1·62	1·62	18	
69	,,	,,	+ 1·39	1·39	16	
70	,,	,,	– 1·02	0·98	18	Candle used by Blackwell colliery miners.
71	,,	,,	– 3·27	0·30	18	Ditto, after burning 30 minutes in a still atmosphere without snuffing.
72	,,	,,	+ 1·66	1·66	18	Test made immediately after candle was snuffed clean.
73	,,	,,	+ 1·04	1·04	18	Same candle after burning 10 minutes.
74	,,	Wax composite.	+ 1·10	1·10	18	Fresh lighted candle.
75	,,	,,	+ 1·07	1·07	18	Same candle after burning 10 minutes.

Such experiments clearly show the difficulty in making photometric tests of miners' candles. There was less fluctuation with wax composite and self-burning plaited wick. A similar experiment was made with wax composite candle of the same number per pound and the results are recorded in experiments Nos. 74 and 75; the candle was fresh-lighted and the test was made directly it had attained its full burning intensity, when it gave 1·10 of that of the safety-lamp; 10 minutes after, both lamp and candle remaining untouched, it gave 1·07, or practically the same illuminating power. This test showed at least one advantage that the wax composite had over the tallow candle.

A comparison of the fourth series of experiments with the third series shows the difficulty of comparing fluctuating lights. Experiments Nos. 49 to 54 show the candles in a much less favourable position than would be anticipated from the results of the experiments in the third series, this was due to the high trimming and maximum intensity of the light given by the safety-lamp.

Experiments Nos. 55 to 60 may easily be compared with the third series, as the safety-lamp used gave practically the light of a standard candle when tested (see experiment No. 28, Table II.), and therefore the results in Table IV., Nos. 55 to 60, should be the same as the results given by similar candles in Table III. A comparison shows that, considering the fluctuating nature of the lights, the experiments were similar in their results.

TABLE V.—EXPERIMENTS MADE WITH A SAFETY-LAMP FITTED WITH 1 AND 2 GAUZES, ALSO WITH AND WITHOUT A WHITE ENAMELLED REFLECTOR AT THE BACK OF THE LIGHT.

No. of Experiment.	Gauzes used.	Comparison.		Remarks.
		Photometric Reading. − Minus. + Plus.	Intensity of Light compared with that of the Standard Candle.	
76	Single	−1·76	0·57	Best colza oil was burnt in the lamp in both tests, the same oil vessel being used.
77	Double	−1·91	0·52	
78	Single	−1·18	0·84	Lille colza and petroleum, the same oil mixture as that used in No. 26 Experiment.
79	Double	−1·39	0·72	
80	Single	−1·04	0·96	Colzaïne, the same oil as that used in No. 28 Experiment.
81	Double	−1·58	0·63	
82	„	−2·23	0·44	Plain clear glass.
83	„	−1·42	0·70	White enamelled reflector.

Fifth Series of Experiments.—Separate experiments (Table V.) were made to test the influence upon the burning of the light due to a single

or double gauze in the safety-lamp. When burning colza oil the light was not much less with two gauzes than with one gauze, but with mineral oil there was a marked decrease of light. With colzaïne there was a material decrease, probably due to such oil requiring a larger supply of oxygen than the vegetable oil. If this be so, the restricted ingress and egress of air by using two gauzes seriously affects the use of mineral oils.

Experiments Nos. 82 and 83, show, as in other experiments, that a white enamelled reflector is a valuable adjunct to a safety-lamp.

TABLE VI.—EXPERIMENT AS TO THE PHOTOMETRIC VALUE OF THE SUSSMANN PORTABLE ELECTRIC LAMP.

No. of Experiment.	Standard Candle burning 120 grains of Sperm per Hour.	Comparison.			Remarks.
		Description of Light Tested.	Photometric Reading. + Plus.	Intensity of Light compared with that of the Standard Candle.	
84	Standard candle	Sussman electric lamp	+1·06	1·06	Practically the same as the standard sperm candle.

Sixth Series of Experiments.—An experiment was made (Table VI.) with the recently introduced Sussmann portable electric lamp* for the purpose of testing its illuminating-power. It was found to give a light equal to the light of a standard sperm candle. The lamp was a new one, and at the time of testing was believed to be fully charged, and was therefore in the best condition for giving its maximum light when its photometric value was ascertained.

Seventh Series of Experiments.—The light given by an illuminant varies with the amount and quality of the materials consumed. The consumption of a standard sperm candle may be a little irregular, but its standard photometric power is governed by the consumption of 120 grains per hour. No such standard of consumption can be fixed for tallow or wax composite candles, so that they may be reduced to a standard of light, but as the amount of light is influenced by the amount of tallow or wax consumed, it was necessary to make a number of experiments to show the rate of burning of such illuminants (Table VII.).

With ordinary candles, the rate of consumption is not always the test of the intensity of light, for the wick must be taken into account. It may be too thick or too thin, and may not consume its fuel to the best advantage.

* *Trans. Fed. Inst.*, vol. vi., page 264.

TABLE VII.—EXPERIMENTS AS TO THE RATE OF BURNING OF CANDLES OF VARIOUS SIZES AND QUALITIES.

	Tallow Candles.							Wax Composite Candles.				
No. of Experiment ..	1	2	3	4*	5	6	7	8	9	10	11	12
Number of candles per pound ...	24	20	18	18	16	14	12	20	18	12	10	9
Weight of candle tested, grains...	315	400	396	421	443	514	583	375	408	615	756	838
Number of wick-threads ...	8	10	10	10	14	14	18	Plat	Plat	Plat	Plat	Plat
Rate of burning, grains per hour	154	201	196	149	208	217	211	132	131	155	161	165
Time occupied in burning one candle in a still atmosphere ..	H. M. 2 3	H. M. 1 59	H. M. 2 1	H. M. 2 39	H. M. 2 8	H. M. 2 27	H. M. 2 45	H. M. 2 50	H. M. 3 6	H. M. 3 58	H. M. 4 41	H. M. 5 5

* This was a blue candle.

This series of experiments (Table VII.) enables a comparison (Ta VIII.) to be made of the rate of consumption, and the intensity of lig of two descriptions of candles, 18 to the pound, burning at differ rates of consumption.

TABLE VIII.

TABLE VII.			TABLE III.	
Number of Experiment.	Candles per Pound.	Rate of Burning, Grains per Hour.	Number of Experiment.	Intensity of Light.
4	18	149	44	1·53
3	18	196	40	1·70

From Table VIII. it will be seen that of two candles of equal burning at different rates, the one burning the greatest number of gr of tallow per hour gives the greatest amount of light.

The wick in wax composite candles is more uniform in size and qua than in tallow candles, and a more accurate comparison may be made the former than the latter.

The experiments summarized in Table IX. show that wax compo candles, 18, 12, and 10 to the pound, gave increased intensity of ligh proportion to the increased quantity of wax consumed, and that can 20 to the pound burning at nearly the same rate as those of 18 to pound gave more light. This fact was proved in two series of tests, can only be accounted for by supposing that the wick was more suit for the size of the candle in one case than in the other.

TABLE IX.

No. of Experiment	Wax Composite Candles.			
	8	9	10	11
Table VII.—				
Number of candles per pound ...	20	18	12	10
Rate of burning per hour, grains	132	131	155	161
Table III.—				
Intensity of light compared with that of the standard candle...	1·56	1·32	1·37	1·50
Table IV.—				
Intensity of light compared with that of the safety-lamp ...	1·27	1·11	1·34	...

TABLE X.—EXPERIMENTS AS TO THE RELATIVE BURNING DURATION OF VARIOUS LAMP-OILS.

No. of Experiment.	Description of Oil.	Proportion used.	Quantity Burnt.	Total Time Burning	Rate of Burning Fluid per Hour.	Remarks.
			Fluid Ozs.	H. M.	Grains.	
1	Safety-lamp oil	...	2	10 50	91	Same oil as used in Nos. 4 and 34 Experiments.
2	Lille colza ... / R. d. petroleum*	¾ / ¼	2	12 17	79	Same oil as used in No. 6 Experiment.
3	Stettin colza ... / R. d. petroleum*	¾ / ¼	2	12 35	78	Same oil as used in No. 9 Experiment.
4	Safety-lamp oil	...	2	12 35	78	Same oil as used in No. 3 Experiment.
5	English rape ... / R. d. petroleum*	¾ / ¼	2	12 40	77	Same oil as used in No. 7 Experiment.
6	Stettin colza ... / R. d. petroleum*	¾ / ¼	2	13 5	74	Same oil as used in No. 10 Experiment.
7	English rape ... / R. d. petroleum*	¾ / ¼	2	13 30	72	Same oil as used in No. 8 Experiment.
8	Lille colza ... / R. d. petroleum*	¾ / ¼	2	14 7	68	Same oil as used in Nos. 5 and 26 Experiments.
9	Safety-lamp oil	...	2	14 12	68	Same oil as used in Nos. 19 and 30 Experiments.
10	Stettin colza ... / R. d. petroleum*	¾ / ¼	2	15 20	63	Same oil as used in No. 13 Experiment.
11	Colzaine ...	...	2	15 35	62	Same oil as used in Nos. 15 and 27 Experiments.
12	Colzaline ...	...	2	17 20	56	Same oil as used in Nos. 2 and 25 Experiments.
13	„ ...	...	2	17 35	55	Same oil as used in Nos. 16 and 28 Experiments.
14	English rape ...	...	2	17 35	55	Same oil as used in No. 17 Experiment.
15	Safety-lamp oil	...	2	18 50	52	Same oil as used in Nos. 1 and 24 Experiments.
16	Foreign colza ...	...	2	...	...	Same oil as used in Nos. 20 and 31 Experiments. Wick burnt away by constant snuffing before the oil was exhausted.

* Royal daylight petroleum.

Eighth Series of Experiments.—Experiments (Table X.) were made to ascertain the rate of burning of various oils, and for this purpose 2 fluid ounces of each description of oil were placed in a clean oil-vessel, trimmed with a dried cotton-wick 3 inches long. The wick was lighted and kept burning at its maximum intensity, without smoking until the oil was exhausted. The full amount of oil in the whole of the samples, except No. 16, was burnt.

The wick in No. 16 experiment was so frequently snuffed and cut, that it ceased to reach the oil in the vessel, and the light went out before the oil was consumed.

In all the tests, the oils were burnt in an open and free atmosphere without glass or cover, the thermometer in the lamp-room standing at 68 degs. Fahr. throughout the tests.

TABLE XI.—COMPARISON OF THE RATE OF BURNING OF OILS, INTENSITY OF LIGHT, AND COST.

No. of Experiments	Oils.				
	Rate of Burning per Hour. (Table X.)	Intensity of Light compared with that of the Standard Candle. (Table II.)	Intensity of Light compared with that of the Standard Candle. (Table I.)	Cost per Hour.	Cost per Day of 10 Hours.
	Grains.			d.	d.
1	91	1·03	0·36	0·0185	0·185
2	79	*	0·34	0·0206	0·206
3	78	*	0·29	0·0183	0·183
4	78	*	0·38	0·0198	0·198
5	77	*	0·30	0·0155	0·155
6	74	*	0·27	0·0193	0·193
7	72	*	0·25	0·0159	0·159
8	68	0·77	0·44	0·0164	0·164
9	68	0·74	0·54	0·0160	0·160
10	63	*	0·32	0·0150	0·150
11	62	0·72	0·45	0·0072	0·072
12	56	0·96	0·39	0·0064	0·064
13	55	1·02	0·47	0·0064	0·064
14	55	*	0·32	0·0150	0·150
15	52	0·87	0·43	0·0112	0·112

* No experiment made.

Comparison of the Rate of Burning, Intensity of Light, and Cost.—Perhaps the most interesting result shown in Table XI. is the cost of oil burnt in safety-lamps. It is probable that from the first lighting of the lamp to its being extinguished, at the end of a full day's work, the time would average 10 hours, and therefore that period has been adopted for the working day of a safety-lamp.

The cost of candles (Table XII.) is based upon their rate of burning in a still atmosphere.

Table XI. shows that the cost of oil for a safety-lamp varies from 0·064d. to 0·206d. per day, while Table XII. shows that the cost of candles varies from 0·75d. to 1·24d. per day. A candle is a self-contained and fully complete illuminant, whereas the total cost of a safety-lamp per day must include renewals, repairs, interest on capital, and cleaning.

TABLE XII.—COMPARISON OF THE RATE OF BURNING OF CANDLES, INTENSITY OF LIGHT, AND COST.

Candles.	Tallow.						Wax Composite.					
Number of candles per pound	24	20	18	16	14	12	20	18	12	10	9	6
Cost per hour, pence	0·083	0·115	0·112	0·119	0·124	0·120	0·075	0·075	0·088	0·092	0·094	0·077
Cost per day of 10 hours, pence	0·83	1·15	1·12	1·19	1·24	1·20	0·75	0·75	0·88	0·92	0·94	0·77

Where a large number of lamps are used the cost should not exceed 0·75d. per day, as will be seen from Table XIII., showing the actual working costs per day of safety-lamps used at coal-mines in the Midland district.

TABLE XIII.—WORKING COSTS OF SAFETY-LAMPS PER DAY USED AT FOUR MINES IN THE MIDLAND DISTRICT.

Collieries.	Oil.	Wick.	Cleaning.	Repairs and Renewals.	Interest on Capital.	Total per Day.
	d.	d.	d.	d.	d.	d.
A, using 1,000 safety-lamps, 5 days per week	1·41	0·010	2·01	0·34	0·08	0·770
B, using 1,060 safety-lamps, 4 days per week	0·49	0·003	2·97	0·37	0·08	0·978
C, using 1,600 safety-lamps, 5 days per week	0·74	0·010	1·64	0·61	0·08	0·616
D, using 1,100 safety-lamps, 5 days per week	0·61	0·009	1·87	0·26	0·08	0·566
	Average cost per day					0·732

GENERAL REMARKS.

Safety-lamps.—Some safety-lamps give better photometric results than others, and certain conditions of construction appear to be essential so as to obtain a good light. Safety-lamps which afford an easy ingress of air direct to the flame, and a free egress for the products of combustion, give the best light, as it is requisite that the flame should have an unlimited supply of oxygen, and that the resultant gases should be rapidly carried away.

The extra gauze in the Marsaut type of safety-lamp material increases its safety, but it retards the ingress of air and the egress of the products of combustion. Some lamps admit air at the bottom, but the area of the inlets is considerably reduced by the covering of gauze, and it is probably owing to the reduced area of the inlets that they do not appear to burn better than lamps of the single gauze type, where the ingress air passes through the gauze and downwards to the flame.

The construction of the modern safety-lamp is not calculated to give free ingress and egress for the air, and the value of free access of air to the flame can easily be seen by burning the light with the lamp-bottom uncovered and free to the atmosphere, and then placing over it the lamp-glass and gauze.

Wick.—The wick should be well dried before being used, and provided that it touches the bottom of the oil-vessel, the shorter it is the better, having due regard for its economical use. To obtain a good light it is better to have a short wick frequently renewed than a long wick burning for a considerable period.

Trimming.—The trimming of the oil-vessel of a safety-lamp is a matter of greater importance than appears to be generally acknowledged. It is often done by boys, and frequently in a rough and careless manner.

The filling of the oil-vessel requires no skill, but the renewal of the wick, the proper fitting of the same to its holder, and the cutting of the wick so that the full width of flame may be obtained are matters upon which the amount of light and free-burning flame largely depend. The cutting or trimming of a wick appears to be a very trivial matter, but many trivial points, when carefully attended to, increase the value and usefulness of the light. A flat wick cut irregularly gives a poor light compared with the same wick cut straight across. In the first case a smoky spiral flame with little light is the result, in the latter a broad light-giving flame is obtained.

Moisture is detrimental to the free-burning and travel of the oil through the wick, and therefore proper provision should be made in the lamp-room for storing ready cut lengths of wick in a dry condition.

The wick should be flat, about ½ inch wide, and should consist of loosely-plaited cotton threads. It should be slightly wider than the wick tube, so that when saturated with oil it will be self-supporting. It must not fit so tightly that the free flow of oil through it by capillary attraction is prevented.

Lamp-wicks may become reduced in their freeness to capillarity or feeding action, by solid matter in the oil being deposited in the wick during the passage of the oil to the flame. This points to the advisability of frequent renewal of the wick.

The construction or plaiting of the wick should be arranged so that although forming a fairly solid body, it should not be so close as to prevent capillary attraction.

Wick-tube.—The wick-tube for a flat wick should be corrugated on one side, and be only slightly less in width than the wick to be used in it.

Some wicks when lighted soon become caked with a crust of burnt wick, this defect in many cases being due to the form or size of wick-tube.

The tube should be a medium for holding the wick in its proper position, and of permitting the flame by capillary attraction to draw an unlimited supply of oil to it. A corrugated tube has been found to be the best form. It not only permits of a free supply of oil, but, to a large extent, it prevents incrustation, and a more uniform and better light is obtained.

The trimming-slot in the side of the wick-tube is frequently too large; in some cases it is so large that when a light oil is used, inflammable vapours escape from it and fire at the flame of the lamp. The slot should be no longer than is necessary to allow the pricker to freely adjust the height of the wick.

The top of the wick-tube, when the lamp-bottom is screwed up, should be about $\frac{1}{2}$ inch above the bottom sight-line of the lamp-glass. The tubes in many lamps now in use are placed too high, diminished light being the result.

Pricker.—The pricker is a very simple, but, at the same time, an important part of a lamp. Many users of lamps cannot cleanly snuff the wick of a locked lamp and retain the light. This is in some measure due to bad manipulation, but it is also due to an awkward form of pricker. The present style of pricker permits of only half the wick being snuffed, the other half being usually removed by a blow of the hand upon the oil-vessel, or by knocking the lamp against some hard substance.

The pricker should be of a form that will reach across the full width of the wick-tube. It should not act parallel to the tube, as that mode

of action would frequently extinguish the light. It should cut across the top by commencing to take the snuff off at one end of the wick, and allow the flame to relight the snuffed part before cutting away the snuff from the opposite end.

The pricker should work easily, but sufficiently tightly so as to remain in any position in which it may be placed, and it should be long enough to allow of its being placed, when out of use, so that it will not interfere with the flame.

It is surprising to find how large is the number of defective prickers in use. Considering that this is the only means which the workmen have of snuffing or manipulating the flame, it is important that the pricker should always be in good working order. Far more attention should be bestowed upon this small part of a safety-lamp than is now given to it.

Glass.—Nearly all the safety-lamps now in use have the light surrounded by a glass cylinder. The glass should be clear, free from flaws, and properly annealed. About 2½ inches of the circumference and the full depth of the glass should have a white enamelled surface to form a reflector. In the absence of enamelled glass, a piece of white paper or tin placed between the glass and the brass standards of the lamp will answer the same purpose, or a portion of the glass may be painted on the outside with white enamel paint. The great increase in the amount of light due to the use of a white background will be seen by reference to Nos. 82 and 83 experiments in Table V.

Workmen when holing frequently use white paper reflectors for concentrating the light, and they also find such reflectors convenient for shading the eyes from the direct light of the flame.

Illuminants.—The results of the experiments clearly point to the conclusion that the value of an oil, for illuminating purposes, can best be known by actual photometric experiment. There are the old and well-known vegetable oils, and the mixtures sold under the head of safety-lamp oil (or some other compound name, as various as the mixtures of tea blenders). The composition of such safety-lamp oils appears to be known only to their makers, but to all outward appearance they, probably, more or less, consist of mineral oil.

Some of the oils tested gave a good light, as proved by the photometric tests, but they sometimes produced a smoky flame. All mineral oils, more or less, have this defect.

Lamp-burning oils of the colzaïne or colzaline class give a good white light when carefully adjusted to produce their maximum flame without

smoking, but the margin between the maximum light and a light which produces a smoky flame is very small; in fact, it appears to require the flame to be just on the margin of smoking so as to obtain the maximum of light; and, further, the decrease in intensity of light is remarkably quick and sensitive if the flame be only slightly lowered below its maximum.

Whenever an oil having a mineral basis is used, it is important that the flame should not smoke, for the soot which results soon becomes deposited at the top of the gauze; and directly this occurs, the workman, finding his lamp beginning to burn dull, raises the flame only to rapidly increase the deposit, and soon renders the lamp unfit for use.

The experiments show that some of the oils classed under the head of safety-lamp oils are good illuminants. They appear to owe their light-giving properties to a mineral oil as a base; in some cases this was proved by the smell, and in others by the flame.

Vegetable Oils.—The vegetable oils tested, such as rape and colza, although both are the product of the same seed, varied in quality and illuminating power. Such seed-oils when burnt alone have a tendency to form a crust and require frequent snuffing, whereas when mixed with petroleum they gave good results. It does not appear that vegetable oils are frequently used unmixed with other oils.

Vegetable and Mineral Oil.—Various mixtures of different varieties of colza or rape oil and petroleum were tested with good results. It is thought that the mixture suggested by the Royal Commission on Accidents in Mines is one of the safest and best illuminants that can be used in safety-lamps, viz.:—A seal or refined colza oil of good quality, mixed with a paraffin oil of a flashing-point not lower than 80 degs. Fahr., in the proportion of not more than one part by measure to 2 parts of the vegetable or animal oil.

Experiments have been made to test if in such a mixture the paraffin or petroleum oil would be consumed in the proportion due to the mixture, or if the oils forming the mixture would separate again and assume their original state. It was found that when the oils were well mixed they did not separate, but continued in a uniformly mixed condition, although the vessels containing the mixture stood a long time absolutely at rest.

When the oils are once thoroughly mixed, the fluid burnt is a uniform mixture from first to last, and for the whole period of burning the light is that due to a relative consumption of the oils in the proportions mixed.

Where such a mixture is used, the vegetable or animal oil and the petroleum should be purchased separately, and the admixture should be made at the colliery. The quality of the oil and the flashing-point of the petroleum can in this way be ascertained before the mixture is made.

The object of the addition of the petroleum is twofold: (1) to reduce the viscosity of the seal or colza oil and to increase its capillarity, and (2) to supply a mixture of hydrocarbon oil that will increase the illuminating power of the flame by rendering it white and clearer-burning than when pure vegetable oil alone is used.

If users of such mixtures do not care to purchase the oil and the petroleum separately and mix it themselves, they should specify the quantity, quality, and proportion of the mixture when ordering from the merchant.

Candles.—The tallow candles used, with one exception, were made of white tallow; the exception being that used in No. 4 experiment, Table VII., it was a blue candle, for which some miners have a particular fancy, as they think that a blue candle gives a better light than a white one. Both blue and ordinary descriptions of candle are made from the same tallow (the colour being due to the mixing of a little green verdigris, a crystalline substance produced by the action of acetic acid on copper, 6 ounces of which is sufficient to colour about 12,000 candles), and it is difficult to believe that the colour of the tallow can increase the light.

The wax composite candles appear to be the better of the two descriptions tested. They are cleaner, have a wick which does not require snuffing, they give about the same light under similar circumstances, and they cost about the same as tallow candles.

Price of Illuminants.—The price of an oil does not appear to be any guide to its value as an illuminant, either in respect of light or lasting properties. Some of the cheap oils compare favourably under the same conditions with higher priced ones, both as to light and lasting power.

The cost of oil per lamp per day of 10 hours varies from 0·064d. to 0·206d., or less than ¼d., the cost of candles under similar conditions being from 0·75d. to 1·24d. per day of 10 hours. This, however, is scarcely a fair comparison, for both tests were made in a still atmosphere, and whereas the figures hold good for oil in safety-lamps, the cost of candles would be more, owing to increased consumption and waste due to the effects of the air-currents.

Ownership of Safety-lamps.—It may appear unnecessary to state that safety-lamps should be the property of the owner of the mine where they are used, and that they should be trimmed and kept in proper condition at his cost. A workman should have nothing whatever to do with a safety-lamp, except as user and custodian during his working shift. The lamps used by workmen should be of an uniform pattern for each mine, and of a type and quality approved by those having the care and direction of the workings. This can scarcely be secured if each workman purchases his own lamp.

Intensity of Light.—It will be found from the experiments shown in Table III., that the light of a newly snuffed tallow or wax composite candle is more than that of a standard sperm candle, but the sperm candle is an uniform burning and light-giving standard, which the tallow candle is not. This fact was demonstrated by experiments Nos. 70 and 71 (Table IV.), where the light of a tallow candle after burning 30 minutes in a still atmosphere without snuffing, gave only one-third of the light it gave when freshly snuffed; but in a mine with a fair current of ventilation such a large deterioration of light would not occur, for the air-current would keep the wick partly snuffed.

With wax composite candles there was little difficulty in maintaining a fair light, owing to the plaited wick burning away.

The light given by a safety-lamp depends upon the height of the flame and its adjustment before being tested. When once adjusted, it is fairly regular for some time if well trimmed and good oil is used.

It would be difficult to analyse or epitomize the experiments beyond what is done in the tables. The only standard of comparison that can be relied upon is the standard sperm candle, and therefore the experiments must be taken as comparative under the conditions named in the explanation of the tables.

Table II. shows what good photometric value can be obtained from a safety-lamp of modern construction, if it be well trimmed. Safety-lamps and candles are compared in Table IV. under the most favourable conditions.

It is difficult to compare fluctuating lights with one another, as different readings occur and an average must be struck.

The trimming of either safety-lamp or candle plays an important part in the intensity and clearness of light, and there can be little doubt, in some cases, that safety-lamps are not giving the light that they would do if practical photometric tests were made by those having the responsibility for their maintenance and use.

Flashing-point.—The flashing-point of animal and vegetable oils is so high that their use is free from danger, so far as vapour given off by them at ordinary temperature or the temperature of the oil-vessel when burning in the mine is concerned, but this is far from being the case with mineral oils, some of which are of a dangerous character, and give off vapour at very low temperatures.

The flashing-point of petroleum for mixing with seal or colza oil should not be below 80 degs. Fahr.; for if one of a lower flashing-point be used, it is liable to give off inflammable vapour from the pricker-hole in the wick-tube, and the vapour may fire at the lighted wick.

The flashing-point of all safety-lamp oils having a mineral base, and all petroleum or paraffin oils or mixtures of the same kind, under whatever name they are sold, should have their flashing-point certified or tested by those responsible for the storage and use of such oils.

The apparatus for ascertaining the closed test flashing-point of mineral oils is rather expensive, but the apparatus for the open test is both inexpensive and easy to make, the requirements being: a gas jet or burner, a copper or brass pan filled with fine dry sand, a test-tube, and a glass rod thermometer registering up to 250 degs. Fahr. The test-tube about three-fourths full of the oil is inserted in the sand which is heated by the flame under the pan, and the bulb of the thermometer immersed in the centre of the oil. A lighted taper is periodically applied to the top of the test-tube and directly the vapour ignites, the thermometer is read and recorded as the open test flashing-point. This is a rough and easy method, but for accurate results the Abel tester and closed test should be used. An open test flashing-point of 100 degs. Fahr. would be equal to 75 degs. Fahr. of the standard closed test, so that all open tests must be reduced for comparison with the statutory requirements.

Conclusion.

The experiments show that there are certain requirements necessary for the purpose of obtaining good light from a safety-lamp, and they demand special consideration if miners are to be supplied with a lamp which will require the least amount of attention and give the maximum amount of light.

To obtain good light from a safety-lamp, cleanliness and care must be the motto of the lamp-cabin, and its full intent and meaning should be strictly enforced. Cleanliness is required in cleaning, trimming, and in renewing the wick and oil, and care should be taken to adopt the best type of safety-lamp, well made, and used with oil and wick that give the

best results after being practically tested. It should be remembered that the price of an oil is no guide as to its light-giving properties, or its suitability for burning in a safety-lamp.

Such a series of experiments as are recorded in this paper could not have been made without material help. The author begs to acknowledge the assistance and facilities afforded him by the gentlemen who assisted in making the experiments, and more especially is he indebted to Mr. Forrett, gas engineer, Mr. M. Deacon, Blackwell colliery, Mr. Elliott, manager, and Mr. Hepplewhite and Mr. Hewitt, H.M. Inspectors of Mines.

Mr. T. A. SOUTHERN (Derby) asked the author whether, in testing the intensity of the light, the flat-wick flame was always kept parallel with the photometer-disc, or whether the position was disregarded? He thought if the pricker was always placed in the position recommended by Mr. Stokes, at the centre and on one side of the flat-wick tube, it would interfere with the light or the reflexion of the light, especially when the lamp was being carried.

Mr. C. J. OLIVER (Chesterfield) suggested that importers and dealers should be required by Act of Parliament to brand clearly upon each cask the actual flashing-point of the mineral oil contained therein.

The CHAIRMAN said that Mr. Stokes' paper was a very valuable one and contained a large amount of most useful information. The members would be better prepared to discuss it at a subsequent meeting. He noticed that in Table XIII. the cost of one set of lamps was much more than another, nearly a third more. Had a lamp-cleaning machine been employed? He was connected with a colliery where a large number of lamps were in use, and he was of opinion that there was a considerable advantage in using such an appliance. He agreed with Mr. Stokes' remarks about the pricker, but asked how it was made to cut right across the wick? The corrugation of the wick-tube, he thought would prove advantageous.

Mr. STOKES, in reply, said that the flame, the disc, and the standard candle of the photometer were adjusted to a common axis before a test was made. The lamp-pricker was attached at the side of the flame, and when out of use it was below the top of the wick-tube. Of course, if the lamp was placed upon the floor in the mine (which was a breach of one of the special rules), the pricker might partly obscure the light.

The pricker was so made and fixed that the flame was cut at an oblique angle, so that one part of the snuff was cut from the wick and the flame relighted the part so snuffed before the end of the pricker had passed over the full breadth of the wick-tube. The wick was raised or lowered by a projecting point, as in the old-fashioned pricker. He thought that the suggested branding of the flashing-point on the cask might be deceptive Regarding the difference in cost in Table XIII. A was more than B In one case, the lamps were cleaned by machinery; in another case the difference in cost was caused by the oil used being more expensive; thus in No. 16 experiment the price of the oil was 9d., whilst in No. 6 experiment it was 1s. 8½d. per gallon. This great difference in the cost of the oil would account for considerable variation in the working cost.

The CHAIRMAN moved, and Mr. W. WILDE (Sheffield) seconded that a vote of thanks be accorded to Mr. Stokes for his interesting paper

The motion was carried, and duly acknowledged.

THE GEOLOGY OF WARWICKSHIRE.

Mr. R. SMALLMAN (Nuneaton) said that the minerals of the county of Warwick consisted chiefly of coal (he could not include ironstone, for it was now valueless), clay, limestone, and roadstone.

Roadstone was derived from two sources—igneous rocks and the so-called Millstone Grit; the latter, which was found close to Nuneaton was Cambrian rock.

The Coal-measures were found chiefly between Tamworth and Coventry. In the northern part of the district, they stretched from Polesworth to very near Tamworth, and thence on the west to Twogates and into the neighbourhood of Kingsbury, where the surface strata were Permian and New Red marls. On the eastern side, Coal-measures were found at Polesworth, and in the directions of Atherstone, Nuneaton, and Bedworth. The outcrops of the Coal-measures were unconcealed between these points; but at Bedworth, they were covered with drift, and this continued to the southern extremity of the coal-field, about 3 miles from Coventry. The northern end of the Warwickshire coal-field was very much like a trough cut square off at the end. About Twogates and Kingsbury on the west, the measures cropped to the surface, and also on the eastern side near Polesworth and Atherstone. The coal in the intermediate district would be 850 feet deep in the centre, rising to very small depths at the extremities. The northern end of the incomplete trough

was 4 or 5 miles square. The south-western side of the coal-field dipped under the Permian measures in the direction of Birmingham and joined the South Staffordshire coal-field. Sir Alfred Hickman at the Tunnel pit, Ansley, had proved at 990 feet in depth, the two-yards coal-seam, and at 1,140 feet, the seven-feet coal-seam, and he (Mr. Smallman) had reason for believing that mining operations would shortly be commenced in that locality. Further south on the eastern side, was the Griff colliery, where the workings were about 750 feet deep, and the Charity colliery, working at depths of 600 and 1,200 feet respectively. These were greater than the depth at Sir Alfred Hickman's pits, where it was 990 feet to the top, or two-yards coal-seam, and he thought at that point the bottom of the basin was nearly reached. Further south, at Exhall colliery, the depth of the shaft was 855 feet, and the deep workings were about 1,350 feet from the surface. During the last three months, a very interesting wash-fault had been found, about 300 feet wide at the bottom of the coal-seam, and 1,200 or 1,500 feet wide at the top. This fault had been caused by the washing away of the coal by the action of water, and it was in the extreme deep. Still further south were the Wyken and Craven workings, at a depth of 1,350 feet.

Clay was largely worked in the neighbourhood of Nuneaton and Tamworth, and limestone near Rugby and Warwick. Roadstone was worked at Mancetter, Hartshill, and Griff; and Warwickshire and the neighbouring counties, especially to the south, were supplied with this stone.

The coal-field was very peculiar in its formation. On the western side, the Coal-measures dipped as much as 80 degs. at Dosthill, where the coal-seams were in contact with igneous rocks; and on the eastern side, at Hauchwood, the dip was 50 degs. In consequence of this tilting of the measures on the eastern side, igneous and Cambrian rocks were intermixed. He had found slate a few feet from his house at Hartshill. Coal was found lying almost on the top of these rocks, within a few feet, showing that many measures had been completely washed away. This would remind the members of the like conditions, which occurred in the Charnwood Forest district, where there were similar strata of Cambrian rocks and greenstone. There seemed to be little doubt that the Central portion of England was high and dry for a long time, during which the other parts were under water.

The Geology of the Warwickshire Coal-field, and the Permian Rocks and Trias of the Surrounding District," by Mr. H. H. Howell, contains valuable information on the subject.

The CHAIRMAN proposed a vote of thanks to Mr. Smallman for his interesting remarks, and hoped that they would be the precursor of a paper on the subject.

Mr. STOKES seconded the motion, and hoped that Mr. Smallman would shortly communicate a paper on the geology of Warwickshire, especially with reference to the continuation of the Coal-measures from Nuneaton to Hampstead, near Birmingham.

The resolution was carried with acclamation, and Mr. Smallman promised attention to the suggestion.

The CHAIRMAN proposed, and the Rev. G. M. CAPELL seconded, a vote of thanks to the Mayor, the Earl of Warwick, for the use of the Court House, which was carried unanimously.

ELECTION OF OFFICERS—1895-96.

The scrutineers, who received the thanks of the meeting for their services, reported the result of the ballot as follows :—

PRESIDENT.

Mr. EMERSON BAINBRIDGE.

VICE-PRESIDENTS.

Mr. A. G. BARNES.	Mr. W. D. HOLFORD.
Mr. G. J. BINNS.	Mr. M. H. MILLS.
Mr. G. E. COKE.	Mr. T. A. SOUTHERN.

COUNCILLORS.

Mr. G. S. BRAGGE.	Mr. C. R. MORGAN.
Mr. P. M. CHESTER.	Mr. R. SMALLMAN.
Mr. W. C. FOWLER.	Mr. R. J. STRICK.
Mr. W. H. HEPPLEWHITE.	Mr. R. THORNEWILL.
Mr. H. R. HEWITT.	Mr. H. WALTERS.
Mr. J. H. W. LAVERICK.	Mr. W. WILDE.

PAST-PRESIDENTS (*ex-officio*).

Mr. G. LEWIS.	Mr. H. LEWIS.
Mr. J. JACKSON.	Mr. A. BARNES.
Mr. J. A. LONGDEN.	Mr. W. SPENCER.

VICE-PRESIDENTS OF PREVIOUS YEAR (*ex-officio*).

Mr. M. DEACON.	Mr. J. B. SMITH.

TREASURER.

Mr. E. EASTWOOD.

SECRETARY.

Mr. W. F. HOWARD.

REPRESENTATIVES ON THE COUNCIL OF THE FEDERATED INSTITUTION OF MINING ENGINEERS.

Mr. E. Bainbridge.	Mr. M. Deacon.	Mr. H. Lewis.
Mr. G. J. Binns.	Mr. W. F. Howard.	Mr. J. A. Longden.
Mr. G. E. Coke.	Mr. J. Jackson.	Mr. M. H. Mills.
	Mr. W. Spencer.	

Mr. A. H. Stokes proposed a vote of thanks to Mr. Spencer for the attention that he had given to the affairs of the Institution during his presidency. He had carefully watched their interest and attended regularly at the meetings of the Institution.

Mr. H. R. Hewitt (Derby), as a member of the Council and on behalf of the Council, seconded the vote of thanks, and at the same time remarked that the Council appreciated Mr. Spencer's diligence and attention to the many duties which he had had to perform. Mr. Spencer had made a record attendance not only at General but at Council meetings, and the Council were glad to acknowledge their indebtedness to him.

The resolution was carried with applause.

The Chairman, in acknowledging the very cordial manner in which the proposition had been made and carried, remarked that he would have liked to have done more than he had, and it was extremely gratifying to him to find that he had attended more meetings than anyone else. He regretted that some of the papers had not, in his opinion, been sufficiently discussed. He wished on retiring to cordially thank the Council and Secretary for their co-operation and assistance during his term of office.

MEMOIRS OF DECEASED MEMBERS.

Mr. John Bloor was born at Pilsley, near Clay Cross on November 7th, 1860, and was educated at Hunt Bridge House, Matlock. At the age of fifteen years he was apprenticed, to Mr. T. D. Croudace, manager of the Clay Cross collieries, to whom he subsequently became assistant. In that capacity he rendered valuable assistance on the occasion of the Park House colliery explosion. He gained his certificate as a colliery manager whilst employed at the Clay Cross collieries. Thence he went to take charge of Kilburn colliery, at which place he remained about three years. He then removed to Diminsdale colliery, where he

stayed till his death on March 21st, 1895, having been at Diminsdale about four years. He was for some years a secretary of a branch of the National Association of Colliery Managers.

He became a member of this Institution on January 14th, 1888.

Mr. GEORGE HEWITT was born at Swanwick, near Alfreton, on November 18th, 1837. He received his education at Risley Latin School; he left when he was fourteen years old, and went to his maternal grandfather, Mr. John Richardson, mining engineer, of Chesterfield, at that time engineer and manager to Messrs. Appleby & Co. for their ironstone-mines at Walton, Whittington, and other places, and to the Wingerworth Iron Co. for their ironstone-mines. Mr. Hewitt acted as surveyor at these mines, and generally assisted his grandfather.

At Mr. Richardson's death, Mr. Hewitt succeeded him as manager of all the above-named ironstone-mines. When the black-shale ironstone ceased to be used he was appointed manager at Messrs. Appleby & Co.'s mines in Northamptonshire, and continued to hold that position in conjunction with his other engagements.

About the year 1870 he was appointed manager of Manvers Main colliery, but relinquished the appointment to become manager of Unstone Main colliery, near Sheffield. He was manager at Unstone collieries until two years ago, when illness compelled him to relinquish all active employment, and he removed to Ashover, where he died on April 17th, 1895.

He became a member of this Institution on April 22nd, 1871, a Councillor in 1885, and a Vice-President in 1890.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

EXCURSION AND GENERAL MEETING,

HELD AT WALSALL, JULY 22ND, 1895.

MR. H. C. PEAKE, PRESIDENT, IN THE CHAIR.

The members visited the James Bridge Steel-works of Messrs F. H. Lloyd & Co. Mr. J. W. Hall and Mr. J. Heming explained the various processes in use at the works and submitted special test-pieces and records.

The members then visited the electrical station of the South Staffordshire Tramways Company. The motive power is produced by three compound horizontal engines, with high and low-pressure cylinders (10½ and 20 inches in diameter respectively), fitted with Corliss valves. Steam is generated in three Lancashire boilers, 30 feet long and 7 feet in diameter. At 100 revolutions, and a boiler-pressure of 120 lbs. per square inch, each engine develops 125 horse-power. The engines drive three dynamos, shunt-wound, by cotton ropes, and at 450 revolutions per minute yield an output of 260 ampères at a pressure of 250 volts. The overhead electric-traction system of the South Staffordshire Tramways Company extends over a length of 8 miles.

REPRESENTATIVES ON THE COUNCIL OF THE FEDERATED INSTITUTION OF MINING ENGINEERS.

Mr. W. F. CLARK. | Mr. W. J. HAYWARD. | Mr. H. C. PEAKE

The following gentlemen having been duly nominated were elected :—

MEMBERS—

Mr. J. L. BALFOUR.	Mr. W. I. SMITH.
Mr. R. BLANE.	Mr. A. WATSON.

The President appointed Messrs. W. B. Scott and J. Hughes scrutineers, and Messrs. W. H. Whitehouse and D. Rogers auditors.

The PRESIDENT moved that the thanks of the members be accorded to the owners of the works visited, and to Mr. Hall, Mr. Heming, and Mr. Dickinson (the engineer of the South Staffordshire Tramways Company) for the interesting information which they had supplied. He added that no plant could be laid out more efficiently and economically than that for the working of the electric system, all the details having been most carefully considered.

Mr. C. H. TREGLOWN, in seconding the proposition, said that competition nowadays demanded the greatest production with the smallest amount of expenditure, and the greatest amount of strength with the smallest weight; and that, for mechanical purposes, was provided by cast-steel. The electric installation seemed to be complete in every respect, and, as compared with the American systems, the members were pleased to see that for simplicity and general arrangement the advantage was entirely with the South Staffordshire Tramways Company.

The vote was cordially approved, and Mr. Hall having replied, the meeting was closed.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

ANNUAL GENERAL MEETING,

HELD IN THE MASON COLLEGE, BIRMINGHAM, OCTOBER 7TH, 1895.

MR. H. C. PEAKE, RETIRING PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and of Council Meetings were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. FREDERICK BROWN, Electrical Engineer, Walsall.
Mr. LANGFORD RIDSDALE, Mining Engineer, Tamworth.
Mr. GEORGE TURNER, Mining Engineer, Cordley House, West Bromwich.

STUDENTS—

Mr. H. G. PAYNE, 64, Trevenson Street, Camborne, Cornwall.
Mr. H. E. C. WHITTALL, 1, Beacon Hill Terrace, Camborne, Cornwall.

The annual report of the Council, together with the Auditors' report, and the Balance sheet, were read as follows:—

ANNUAL REPORT OF THE COUNCIL.

The Council have pleasure in submitting their twenty-eighth Annual Report, and in congratulating the members upon the success of the past year.

The Institute has held four General Meetings, and one Excursion, together with six Council Meetings and one meeting of the Technical Education Committee.

Seventeen new members have been elected, two have died, five have resigned, and, unfortunately, eleven, an unusually large number, have been struck off by the Council in accordance with the Rules for non-payment of subscriptions. The members' roll consequently numbers 136 as against 137 last year.

The total receipts have been £207 2s., the expenditure £210 8s. 8d., and there is a reduction of the bank balance of £3 6s. 8d., leaving it at £314 12s. 8d. There would have been a considerable surplus, had it not been for the large and exceptional contributions to the funds of The Federated Institution of Mining Engineers, to the amount of £146 18s. 11d., out of the above total expenditure of £210 8s. 8d., and more than double that paid last year. This has arisen, owing to the contribution per member being higher, more members having been paid for, including several who paid up arrears of subscriptions, and special calls have been paid to make up the deficiencies in the accounts of The Federated Institution of Mining Engineers, for the years 1892-3 and 1893-4, together with the cost of exchanges, excerpts, etc.

The President delivered an interesting inaugural address upon the eight hours' system in collieries; Mr. E. J. Bailey read a paper upon "Electric Haulage by the Main-and-tail Rope System;" Dr. Lapworth contributed largely to the discussion upon Mr. D. Jones' paper upon "The Structure of the Forest of Wyre Coal-field;" and Mr. F. G. Meachem gave some information as to the effect of a poisonous vetch upon the horses at Hamstead colliery. There has been a great dearth of papers, which is probably due to the time and attention devoted to the recent visit of The Federated Institution of Mining Engineers to this district.

The meeting of The Federated Institution of Mining Engineers in Birmingham in February last was undoubtedly the most interesting event of the year, and the papers read were of an important nature. The Annual Report of the Council of that Institution thus speaks of the matter:—

> The subject of inland navigation was considered in several valuable papers read at the South Staffordshire meeting, by gentlemen specially competent to deal with the subject. Mr. Lionel B. Wells placed a valuable "Map of Canals and Navigable Rivers of England and Wales" at the disposal of the Council, and it is reproduced as Plate XXV., of vol. viii. of the *Transactions*. The Council are of opinion that these papers and the accompanying discussions afford valuable information on the important subject of the inland navigations of Great Britain.

The excursions were instructive and enjoyable, and the whole proceedings gave general satisfaction.

The Federated Institution of Mining Engineers continues to flourish, and there are now over 2,300 members. General meetings have been held in the North of England, South Staffordshire, and London, and a large number of excellent papers, varied in subject, have been communicated, necessitating the *Transactions* being published in two volumes.

A meeting of Students and Associates has also been organized, and a prize awarded for the best essay upon "The Prevention of Accidents in Mines."

The Technical Education Committee of this Institute has continued its work in connexion with the Mining Instruction Scheme of the Staffordshire County Council.

Arrangements have been made for the use of a room, in connexion with those of the Secretary, in Colmore Chambers, 3, Newhall Street, Birmingham, where the books and papers of the Institute will be deposited, and where the members may have access to them during business hours. In addition to other useful works of reference, the transactions of the following societies are regularly received :—Illinois Mining Institute, Mining Society of Nova Scotia, South Wales Institute of Engineers, General Mining Association of the Province of Quebec, British Society of Mining Students, Institution of Mining and Metallurgy, Manchester Geological Society, and the Revue Universelle des Mines et de la Métallurgie. Accommodation has also been provided for the models, relics, and plans belonging to the Institute in the Engineering Museum at the Mason College.

The best thanks of this Institute are due and are hereby tendered to the authorities of the Mason College for providing rooms for the meetings.

The Council in conclusion would again strongly urge upon members the necessity for continued individual effort in promoting the interests of the Institute, by contributing papers and in securing new members and especially Students and Associates.

Dr. THE TREASURER IN ACCOUNT WITH THE SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS, FOR THE YEAR ENDING JULY 31ST, 1895. **Cr.**

	£	s.	d.		£	s.	d.
To Bank Balance	317	19	4	By Subscription to The Federated Institution of Mining Engineers from August 1st, 1894, to July 31st, 1895, and Charges for Exchanges, Excerpts, and former Deficiencies of the said Institution	146	18	11
„ Subscriptions Received	203	0	0	„ Secretary's and Reporter's Fees for the Year	50	0	0
„ Bank Interest	4	2	0	„ Printing, Lithography, and Stationery	5	17	7
				„ Stamps, Post-cards for Circulars, Wrappers, Telegrams, Carriage of Parcels, Porterage, etc.	3	19	4
				„ Expenses of Darlaston Excursion, Balance of The Federated Institution of Mining Engineers Meeting Expenses, Auditors' Fees, etc.	3	4	10
				„ Bank Charges	0	8	0
				„ Balance in Bank	314	12	8
	£525	1	4		£525	1	4

BALANCE SHEET, 1894-5.

Liabilities.	£	s.	d.	Assets.	£	s.	d.
Nil.				By Cash at Bankers	314	12	8
To Balance	350	4	2	„ Subscriptions due	35	11	6
	£350	4	2		£350	4	2

Examined and found correct,

DANIEL ROGERS.
September 30th, 1895. WILLIAM H. WHITEHOUSE.

This is exclusive of considerably more than £100 worth of property, for which no credit is taken.

Mr. J. H. COOKSEY moved the adoption of the reports of the Council and of the Auditors.

Mr. W. J. HAYWARD seconded the resolution, which was agreed to.

ELECTION OF OFFICERS FOR 1895-96.

The Scrutineers reported that the following gentlemen had been elected:—

PRESIDENT—Mr. J. H. COOKSEY.

VICE-PRESIDENT.—Mr. R. S. WILLIAMSON.

NEW MEMBERS OF COUNCIL.

Mr. E. B. MARTEN.	Mr. E. HOWL.
Mr. W. H. GLENNIE.	Mr. H. W. HUGHES.

Mr. J. H. COOKSEY, the newly elected president, then took the chair, and delivered the following inaugural address:—

PRESIDENTIAL ADDRESS.

By JOHN H. COOKSEY.

I feel it to be a very great honour which you have conferred upon me to-day in electing me as President of the South Staffordshire and East Worcestershire Branch of The Federated Institution of Mining Engineers. It is an honour that I very much appreciate, but at the same time I fear the position is one I shall have some difficulty in fulfilling to the satisfaction of my fellow members, especially when I compare my qualifications for the office with those of gentlemen who have preceded me, and who have filled the post with much usefulness to the Institute and credit to themselves. I also consider that I am occupying a place which would better have been filled by one of many of our members, whose connexion with the Institute, although it may not have been so long as mine, has been nevertheless of a more active character, as shown by the valuable contributions which they have from time to time made to the *Transactions*.

There is no doubt that since the establishment of our Institute, nearly 30 years ago, a considerable change has come over the practice of mining engineering. Although no word can be said in depreciation of the practical or scientific attainments of the fathers of the profession to whom the present generation owe so much, yet it must be admitted that the mining engineer of the present day requires to have a fuller knowledge than formerly of those branches of science which are now more than ever closely allied with the pursuit of mining. This change I take to be one of gradual development, brought about partly by the requirements imposed upon mining by the Legislature, but mainly, I consider, by circumstances. The increase in the demand for coal both for manufacturing and domestic purposes, the additional difficulties of mining at greater depths than formerly, the consequent necessity for improved methods of winning and working coal and other minerals with a view to economical production, and a host of other requirements which will suggest themselves to you without further enumeration, make it imperative that the mining engineer should be equipped not only with

practical acquaintance with mining in all its branches, combined with a considerable knowledge of mechanical science, but also, and the necessity for this is daily increasing, should possess an acquaintance with the principles of the science of electricity, which has of late years so rapidly come to the front, and is being applied in so many ways in the conduct of mining operations.

There can be no question as to the value of an Institute like this both to the student in mining or to the engineer practically engaged in the working of collieries, whose business it is not only to have due regard to the safety of the miners who are exposed to the many and varied dangers of a hazardous occupation, but who also has to study the interest of his employers in the adaptation of such means and appliances as to secure the best return for capital employed. While every colliery must present features which are to a great extent stereotyped, yet at the same time each one has its peculiar dangers and difficulties, involving constant care and watchfulness on the part of the management, and it appears to me that one of the many uses of an Institute like ours, connected as it is by federation with the kindred institutions of the country, is to afford means of intercommunication of ideas and principles of practice, both by the publication in the *Transactions* of papers on subjects relating to mining and the allied sciences, and by opportunities for the interchange of ideas and results of experience presented by the periodical meetings of each Institute and of The Federated Institution of Mining Engineers.

It is not given to every one to possess the art of placing upon record in an intelligent manner the interesting circumstances which come under notice in daily experience, but it is fortunate for the Institutes generally that there are among the members gentlemen who have this faculty and who willingly devote the necessary time and trouble to place their observations before their fellow members. In proof of this I have only to refer to papers which from time to time are read before the various branches of The Federated Institution of Mining Engineers and published in the *Transactions*, papers touching upon subjects which are of great practical value, and evidencing on the part of the writers intimate acquaintance with their subjects, and proving that a large amount of care and patience, as well as of time, must have been devoted by the authors to the preparation of the papers and accompanying illustrations. I do not wish my remarks to convey that because all the members do not contribute papers those who do are the only ones who possess the art to which I have just now referred, because I have no doubt that there is a good

deal of latent talent among the silent members, only awaiting a fortuit concourse of circumstances to awaken it into vigorous action for general benefit.

I regard as among the most interesting contributions to the lit ture of The Federated Institution of Mining Engineers those papers discussions relating to the effect of mining operations upon the surf and buildings, and it occurs to me that although much valuable inform tion may have been given on this subject, there is no doubt a gre deal more which might be brought forward before it can be exhausted. As the subject is one which in our own immediate district frequently engages the attention of the mining engineer, and there are many of our members who have had extensive experience therein, it is to be hoped that during the coming year some may be induced to record their observations thereon, and so lead to useful discussions.

I think it is agreed on all hands that it is impossible to lay down any hard-and-fast rule which will be applicable in all cases where it is necessary to deal in practice with the question of the effects of subsidence, and it may not be out of place, although treading on ground more or less familiar to all, to recall to mind that the circumstances which affect a consideration of the subject are varying, and to enumerate some of them as follows :—

The depths and thicknesses of the seams to be worked.

The methods of working.

The inclination of the strata.

The nature of the strata intervening between the surface and the seam or seams to be worked, whether they consist solely of ordinary Coal-measures or partly of Coal-measures with superimposed drift, or unconformable strata.

The occurrence of faults.

The presence of bands of thick rock in the intervening strata.

The effect of underground working upon a surface which has already been disturbed by previous mining operations, the result of which will be influenced by the lapse of time since previous workings, and whether such workings were made in an upper or a lower seam.

These are some of the phases of the subject which I have not mentioned to-day with a view of making any special remarks thereon, but to suggest the great importance of it, and I think you will agree with me that it is of such a nature that only observation and experience can guide the mining engineer to correct conclusions where so many causes combine to produce such diverse effects.

I do not mean to imply by calling special attention to the subject of subsidence that I consider it to be of such paramount importance as to exclude the consideration of all other subjects, but only instance it as one of many which might be usefully taken up by the members as bearing upon a question with which most mining engineers have frequently to deal in the course of their practice.

One of our Past-Presidents, Mr. W. F. Clark, in his interesting and instructive address* to the Institute on the operations of the South Staffordshire Mines Drainage Commissioners, gave it as his opinion, arrived at no doubt after careful consideration of the sources of information at his disposal, that the part of the drainage-area known as the Tipton district, comprising a net area of about 11,000 acres, contained a quantity of ungotten coal, which might be estimated at about 70,000,000 tons, an average estimate compared with that of the Drainage Commissioners of 100,000,000 tons and 50,000,000 to 55,000,000 tons, being that of the gentlemen whom Mr. Clark named as engaged in 1885 to make an independent report for the information of the bondholders. These are very large figures, and the work of the Drainage Commissioners in endeavouring to free these mines from water will be recognized as very important. Now that the sum of £100,000, which Mr. Clark referred to in his address as being within measurable distance, has been practically obtained, it is to be hoped that the operations contemplated by the commission, an account of which has recently been before the public and is my reason for referring to it, will be the means of freeing this extensive area from so disastrous an incubus, and this work if successfully accomplished, must inevitably add to the prosperity of the district so long handicapped by such a serious drawback to its commercial prospects.

In an address of this kind to engineers who are closely connected with the raising of minerals, the consumption of which is so bound up in the welfare of the community, it cannot be out of place to express a hope that trade which has generally been in an unsatisfactory condition for so long may be on the eve of a revival, and that this is the case appears to be the general opinion of those who have any claim to speak with authority on the subject. That there are signs of it, I think, is apparent, and it is to be hoped that the revival will have a more permanent character than that of a mere spurt which comes to raise hopes in the breasts of the long-suffering coal-master and manufacturer—hopes destined to be speedily blasted by a recurrence of depression.

I will not attempt to define the causes which have resulted in so long a period of comparative stagnation, nor to reconcile conflicting opinions

* *Trans. Fed. Inst.*, vol. iii., page 465.

thereon, neither will I make any endeavour to explain the reasons for the anticipated revival, as I do not feel myself at all competent to deal with so complicated a question. I can, however, express my satisfaction that there are hopes of better times, not only because when fully established they must beneficially affect the many members of this Institute who are connected with the coal trade and the allied industries, but they will also be a source of unbounded satisfaction to the general community.

I fear that the few remarks I have been able to present to you to-day are hardly worthy of the occasion, but I have suffered from a difficulty, which I trust you will appreciate, in finding a suitable subject on which to found an inaugural address of any length, mainly because the ground has been so well trodden by past presidents of the Institute, that it is not easy, at all events in my case, to select a theme that is both new and attractive.

I hope, however, you will deal leniently with any shortcomings on my part, and in return for an endeavour to do what I can during my year of office to promote the welfare of our Institute, I must ask you on your part to afford me that assistance which I feel I shall greatly need to enable me adequately to fulfil the duties which lie before me.

The PRESIDENT said that he had now to perform the pleasant duty of proposing a vote of thanks to the retiring President (Mr. Peake) for his services during the past year. He (the President) had unfortunately not been able to attend all the meetings of the Institute during Mr. Peake's term of office, but he had no doubt that Mr. Peake had performed his duties to the satisfaction of the members. Mr. Peake's term of office would be memorable owing to the visit of the members of The Federated Institution of Mining Engineers to Birmingham, and there was no doubt that the arrangements made for their accommodation and entertainment during their stay in that district had met with general satisfaction.

Mr. C. H. TREGLOWN said he had the greatest pleasure in seconding the motion proposed by the President. He would only express a hope, although Mr. Peake had retired from the presidential chair, that he would continue to give the Institute the benefit of his knowledge and experience.

Mr. PEAKE replied, assuring the members that he should continue to give his assistance to the Institute.

Mr. W. B. COLLIS moved, and Mr. BAILEY seconded, a resolution conveying a vote of thanks to the officers.

MINING RELIC.

Mr. W. B. Scott said that Messrs. Hough & Son, of Walsall, discovered a few days ago an interesting old relic, which he was deputed by them to offer to the Institute, to be placed in the Museum. It was in the shape of a bowl made of strong oak, and was used no doubt in the shallow mines about Walsall for the purpose of scooping water. It was probably 150 years old, and it showed what advances mining had made, when they learnt that water was then scooped up in such a way and lifted up the shaft by means of a "cheese-box."

The President moved that a vote of thanks be accorded to Messrs. Hough & Son for the present.

Prof. Smith seconded the motion, which was cordially adopted.

Mr. I. Meachem, Jun., then read the following paper on an "Electric Power-plant at Haden Hill Colliery":—

ELECTRIC POWER-PLANT AT HADEN HILL COLLIERY.

By I. MEACHEM, Jun.

Early in the present year it was found, owing to extension of workings, that the then existing haulage-machinery was inadequate, consequently, owing to the increase of horses the cost of haulage became a serious matter. It was therefore determined to increase the mechanical power to cope with the increased distance and output. The first consideration naturally was, could the power of the present appliances be increased sufficiently to meet the requirements of the case? In order to do this effectually, it would be necessary to erect a more powerful haulage-engine with boilers. Even then the trouble would not have been ended, because, owing to certain peculiarities of the mine, the motive power was required at a distance of 660 feet from the pit-bottom, and up a vertical height of 27 feet. This was felt to be a serious difficulty, as the carrying of driving-ropes along a main-road, and round a right-angle in the road, was not a light matter, and even if accomplished, it would be a source of constant trouble.

Attention was then directed to electric power, and after careful examination of electric plants in the North of England and in Scotland, the question of electric power was thoroughly examined, and, without entering into all the arguments in favour of or against its use, the following were the main considerations which led to its adoption :—

1.—The fact that an engine and steam boilers were lying idle, in good order, and sufficiently powerful to generate power considerably in excess of what would be required. This plant was situated about 1,500 feet from the pit-top.

2.—The comparative ease with which electric power could be conveyed and distributed to any point or a number of points where it might be required.

3.—The pumping of water could be dealt with by the electric power. The quantity of water, although not great, was a costly matter when pumped by hand.

4.—The insetts and main-roads could be lighted by electricity.

5.—The ventilating-fan, which was about to be erected, could be driven by an electric motor.

Looking at it from the standpoint of haulage by electricity no distinct gain was apparent, but as a ready means of applying power to other purposes from a central power-station, the gain became obvious.

The generating-plant consists of a horizontal steam-engine, formerly used as a winding-engine, but altered and adapted to its present work. The engine, by means of belting, drives a counter-shaft, which in its turn drives the two dynamos. The engine runs at 42 strokes per minute, driving the haulage-dynamo at the rate of 800 revolutions per minute, and the lighting-dynamo at 840 revolutions per minute.

The large Sayer dynamo, driving the haulage- and fan-motors, is shunt-wound, is capable of developing, when running at a speed of 800 revolutions per minute, 450 volts, and a current of 75 ampères, equal to about 45 horse-power; it is set on a brick foundation with sliding-rails and set screws to take up the slack of the driving-belt.

The small Sayer dynamo supplying light, and driving the pump-motor is also shunt-wound, and capable of developing, when running at a speed of 840 revolutions per minute, 220 volts, and a current of 54½ ampères, equal to about 16 horse-power.

The dynamos and motors are fitted with self-feeding lubricators, and beyond the necessary care in attending to the lubricators and cleaning, require little attention.

The power and lighting cables are all armoured and concentric. The cable from the dynamo to the haulage-motor consists of a positive lead in the centre of 19 copper wires of No 16 gauge. This core is highly insulated, and over the insulation are laid the copper wires of the outer concentric conductor; the whole is then enclosed in a leaden tube, which in its turn is covered with a non-conducting material, serving as a cushion between the leaden tube and the armouring of galvanized iron wire which completes the cable. Both the leaden tube and the iron wires assist the return lead. The lighting and pumping cable to the distributing centre consists of 19 copper wires of No. 18 gauge, the positive lead being insulated and covered similarly to the haulage cable. The cables are very flexible, and are suspended by means of leather hangers from stranded steel wires stretched on poles about 30 feet apart. The cables are taken direct from the generating station to the distributing centre, 1,680 feet distant, near the pit-top. Here the large cable enters a distributing-box, whence two cables are taken, one to the fan-motor, which is in the distributing-house, and the other down the pit to the haulage-motor. The cable from the small dynamo is also distributed, and the power taken by two 7/16 cables from the pit, one for lighting

and one to the pumping-motor. A cable is also taken to the winding-engine house, and from thence distributed in small cables to light the engine and boiler-houses, pit-bank, etc.

In the shaft, the three cables are secured by means of strong wooden cramps built into the side of the shaft, and held by ½ inch coach-screws.

From the insett to the motor-house, the cables are hung with string on to the road-trees, so as to be readily detached when repairs to road are required or timber is being renewed.

Haulage.—The haulage motor-house is situated at a distance of 660 feet from the insett, and 3,300 feet from the generating-station. The motor is of the same size as the large dynamo, the armatures of the haulage-motor and of the large dynamo being interchangeable, so that in case of accident to either, a spare armature, which is kept in readiness, can be attached either to the large dynamo or to the haulage-motor. The haulage-motor runs at the speed of 700 revolutions per minute, and is speeded down on the first motion with belting, and on the second and third motions with gearing, so that the rope driving-pulleys make 4½ revolutions per minute. The motor is enclosed in a cast-steel case, not so much in case of danger from sparking as to preserve the armature from dust and risk of injury.

The motor-house is placed on the highest part of the main-road (the roads dipping from the motor-house in either direction), so that when the rope is loaded, both the intake and outgoing ropes are always taut, thus obviating the necessity for using jockey-pulleys.

In the motor-house is a four-contact starting-switch, enclosed in a circular box with resistance-coils, by means of which the current can be gradually put on and the machinery started slowly. There is also a cut-off switch.

The haulage-arrangement is in two sections (Fig. 1, Plate IV.). The first rope commencing at the motor-house, takes the loaded tubs down the hill to the insett. Passing by the bottom of the shaft, it picks up all the empty tubs, takes them along the intake road a distance of about 960 feet. The empties are then divided, part of them going on with the rope to No. 1 district, about 720 feet further, where they are detached, and loaded tubs attached to the rope and taken on to the motor-house, and thence to the shaft.

Another rope from the motor-house runs empty to a point where the empty tubs detached from the first rope are clipped on and taken into No. 2 district, to a point 900 feet distant from the motor-house, where the empty tubs are taken off, part being sent on down the main-road by

horses, and the remainder are brought to a point where they are run down a dip road with an inclination of 1 in 7 for 240 feet, with a jig-chain. The loaded tubs from the bottom of the jig-hill are brought up in journeys of two, the jig-chain being attached to the haulage rope, and so brought up the hill.

About 500 tons of coal per day is being dealt with by these two haulage-planes. The machinery and motor, however, is capable of dealing with upwards of 700 tons of coal per day.

The first rope-driving wheel is fixed on the driving-shaft, and starts work with the motor. The other rope is attached to a loose driving-wheel, which is set in motion by an Edmeston friction-clutch.

Necessarily, the work of the haulage-motor is very variable, fluctuations of about 25 ampères taking place in a few seconds, mainly due to the attaching of two loaded tubs at the bottom of the jig-hill, to be pulled up an incline 240 feet long, with a gradient of 1 in 7 (Fig. 2, Plate IV.), and yet the speed of the rope is regular.

Lighting.—At bank, the smith's and carpenters' shops, boiler-house, and engine-houses are lighted with sixteen 16 candle-power lamps, and the pit-top with four 50 candle-power lamps. Down the pit there are thirty 16 candle-power lamps, illuminating the insetts, motor-house, and the main-roads, where lights are needed, for a distance of 1,500 feet from the shaft. The men work much better, being able to handle and clip more tubs than was possible when lamps or candles are in use. Not only does the steady light enable men to work in greater comfort, but there is an absence of noxious fumes; and even the main return air-current is sweeter and purer (Fig. 1, Plate IV.).

Pumping.—Near the insett is placed a small Tangye pump and a series-wound motor for raising the sump water. This pump has required little attention beyond oiling. A cable is laid along the road for a distance of 1,500 feet from the insett, and a spare pump and motor provided there for use in case of need.

Fan.—A Capell fan, 6 feet in diameter, is driven at 250 revolutions per minute by an electric motor, using 400 volts and a current of 18 ampères, and affords satisfactory results.

There is also, both in the pit and at bank, a complete system of electric signalling and telephones, which are found to be of great service and saving of time to all connected with the working of the plant.

It was not expected that electricity applied to haulage alone would effect any great saving, yet experience shows that it is more even and reliable in its working than the former method of driving by a band-rope down the shaft, worked by an engine on the surface. The coal is delivered to the pit-bottom so regularly and smoothly that the increase in the daily output is very marked, being nearly 10 per cent., which in itself is a most valuable consideration.

It is expected shortly to lengthen the haulage system a further distance of about 300 yards in each district, for which there is ample surplus power.

Altogether, the writer has every reason to be satisfied with the electric installation.

The writer has not detailed the financial features of the installation, inasmuch as it has not been in operation a sufficient length of time to justify his entering into it.

Mr. I. MEACHEM, Jun., replying to several questions, said that the balance of the costs of the two systems of haulage by steam and electric motors was in favour of the former, if it were a question of haulage alone; but at Haden Hill colliery the question of transmission, for pumping water, for ventilation, and for lighting was equally important. When all these items were taken into consideration there was a large margin in favour of electricity.

Mr. F. G. MEACHEM read the following paper on "Poisoning of Horses by Lathyrus Sativus":—

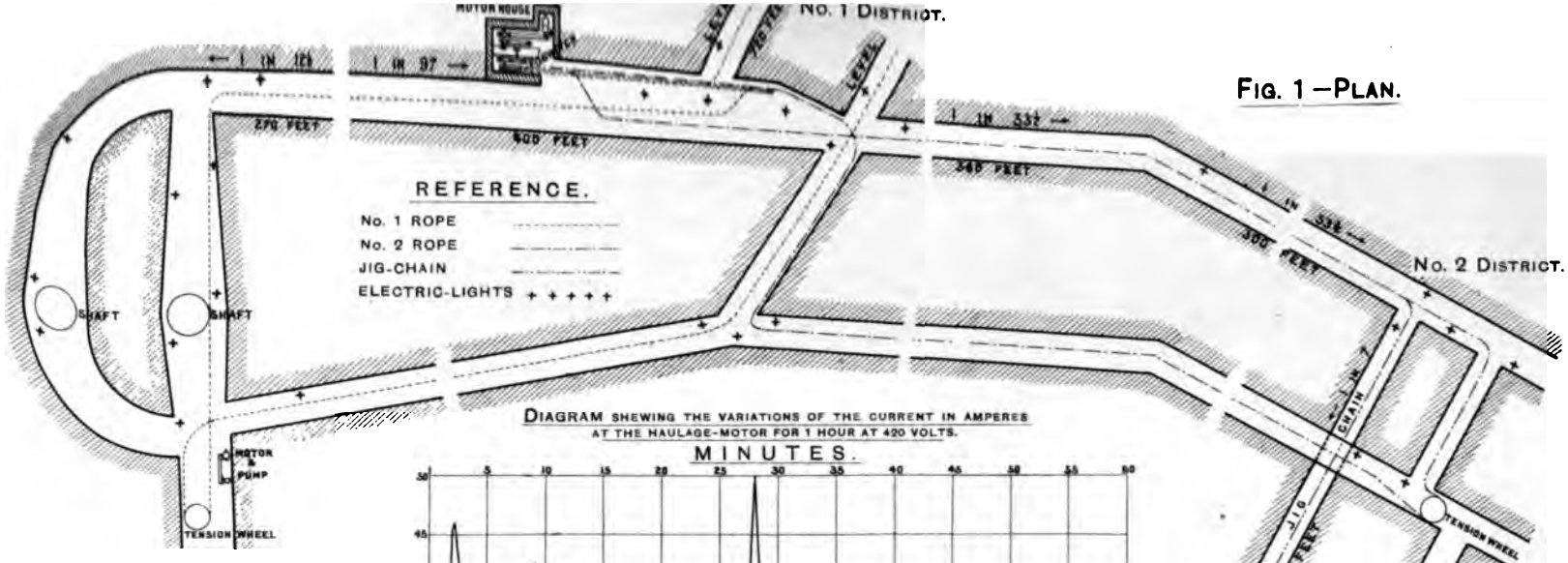

FIG. 1 —PLAN.

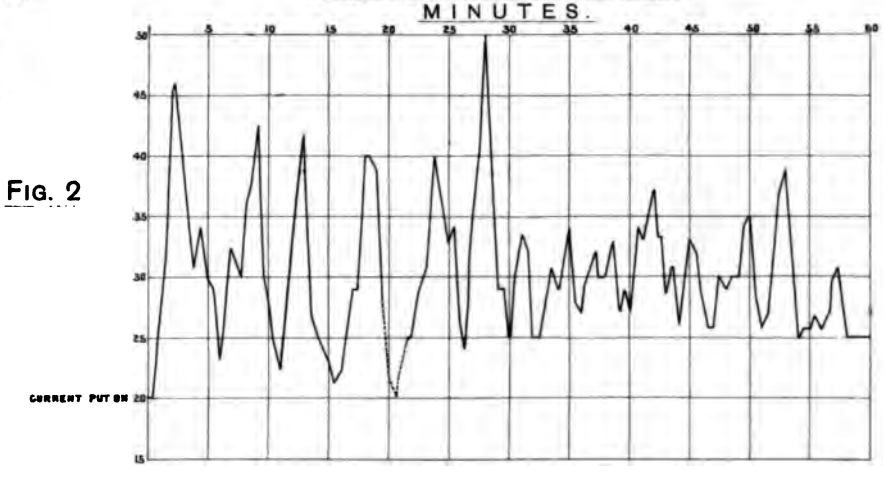

FIG. 2

And.ᵂ Reid & Comp.ʸ L.ᵗᵈ Newcastle on Tyne

POISONING OF HORSES BY LATHYRUS SATIVUS.

By F. G. MEACHEM.

Sometime ago, owing to the high price of horse-feed, peas were used at the Hamstead Colliery in the place of oats or beans, and this was continued for over twelve months without any ill-effects upon the horses.

Early in November, 1894, however, the writer noticed that the horses seemed to be getting thick in the wind, and after running a few journeys would pant and stretch out their necks in their efforts to regain breath. For three or four days the writer thought the collars worn by the horses were too tight, and the attention of the veterinary surgeon (Mr. Pickworth) was directed to the condition of the horses. He could afford no explanation as to the cause of the illness, but gave the horses cooling medicine and watched them for some time, particularly while they were at work. On November 7th, 1894, the writer ordered several of the horses to be put into the stables. After a consultation with the veterinary surgeon, it was decided to change the food, and this seemed to be of benefit for a few days; but afterwards the horses became rapidly worse in spite of continued attention.

Towards the middle of November, one of the horses died, six others were seriously ill at the time, and three of these died in four days.

While Mr. Kidd and the veterinary surgeon were examining the horses, one of them was seized with a kind of fit, reared up, fell over backwards, stretched out his neck, and, fighting for breath, died in a few minutes from suffocation, the breathing muscles appearing to be paralysed.

Several *post-mortem* examinations were made, and samples of blood, together with some of the food, were sent on December 20th, 1894, to Prof. Williams, of the Veterinary College, Edinburgh, accompanied by the following statement:—

I have to-day forwarded for your examination two samples of blood from horses that have died under what I consider extraordinary circumstances.

History of the cases that have died.—The subjects of this investigation are horses working in a coal-mine. About two months ago my attention was called to several of the horses that the waggoner informed me were doing badly, and seemed (as he termed it) short of breath after the least exertion. I asked for full particulars as to diet, etc., and was informed that they were being fed on peas, maize, oats, and chaff. The horses were living in a mine at a temperature of about 80 degs. Fahr. I considered that the diet was unsuitable, and advised that the horses

should have a liberal supply of bran, oats, and chaff, and this was supplied to them from the time mentioned. About a fortnight ago 2 of the horses died suddenly, and since then 5 others have died under precisely the same conditions. Together with Mr. Kidd, of Wolverhampton, I have made *post-mortems* on two of the horses. We could find nothing to account in any way for their death.

The horses which died came out of the stables quite lively, and to an ordinary observer seemed to be in apparent health. After trotting at a good brisk pace or being put to work they suddenly fell over and died from asphyxia. They made a most peculiar noise in the throat during these convulsive fits until death terminated their struggles.

A sample of blood marked A was taken to-day from a horse that died yesterday in the same manner while at work.

The sample labelled B was taken from a four-years-old horse that died in my presence to-day. He came out of the stable, kicked and seemed very fresh, looked perfectly well; after going a good sharp trot for about 500 feet he fell, and died in about five minutes, presenting the above-described symptoms. The pulse was in no way affected, and the membranes and temperature were normal.

Three of the horses have been in the mine for some years, and the others have only been in a few months.

The blood appeared very dark in colour, and of a tarry consistence. All the viscera presented healthy appearances, and there were no signs of blood extravasations.

Will you kindly examine the samples I have sent, and give me your opinion as to the origin and nature of this (to me) mysterious disease?

I may say, in conclusion, that all the horses (numbering over 70) are regularly fed, have good diet, and a good supply of pure water, and are well attended.

All the deaths have occurred to horses working in the mine; those working on the surface are all well, although fed on exactly the same diet.

Prof. Williams, replied asking for some of the food, and samples of the horses' corn containing the peas were forwarded to him. He at once detected the presence in the food of the seeds of *Lathyrus sativus*, a poisonous vetch, which he declared to be the cause of the death of the horses, as shown by the following reply :—

I have got to the bottom of the mystery, for undoubtedly the horses have died from the effects of *Lathyrus sativus* poisoning, an account of which you will find in the *Veterinary Journal* for this month. The samples received this morning are those of the true large white vetchling, with a few round peas amongst them.

Although the use of the peas had been stopped before any of the horses died, the symptoms of the poisoning continued. In all, 12 horses died, and 4 others would no doubt have died had not the operation of tracheotomy been performed upon them. This gave them relief, they are living, but are certainly permanently injured.

A friend of the writer who had spent some time in India recognized the seeds as those of a vetch-like plant, which was refused as fodder in the military stables owing to its poisonous nature. He further remarked that the seeds were frequently smoked as a remedy for neuralgia, the pain being removed, but the back of the head became very sore. The writer

noticed that all the affected horses had a like soreness between the ears, and could not bear to be touched.

Prof. Williams has kindly supplied the writer with the following information :—

There are several varieties of *Lathyrus sativus*, showing slight differences in colour of flower, size and colour of seeds, in colour of foliage (darker or lighter), and strength of growth. Two varieties may be especially mentioned :—(1) *Lathyrus sativus*, with small dark-coloured seeds, known in India as *khesâri* pulse or *latri*, or *matar*. The terms *matar*, *muther*, *mutter*, are all names used in India for peas generally, and the *Lathyrus sativus*, imported from India, is well-known in Britain under the name of "mutters;" (2) *Lathyrus sativus*, the white variety, with larger pale-coloured seeds, which are popularly spoken of as the seeds of the dog-tooth vetch, or the dog-tooth pea.

Many enquiries have been made as to what genus or species these latter seeds may be referred. Through the kindness of Prof. Balfour, plants have been reared from the large wedge-shaped seeds, with the result that the seeds are seen to belong to *Lathyrus sativus, weisse*, the white-flowered variety of the Continent, a result confirmed by Prof. Noble, one of the greatest living authorities on seeds.

Lathyrus sativus, although an annual, may be treated as a biennial by planting late, say in early autumn, when, by due care and in favourable conditions as regards soil, the plant will flower in the spring. The leaflets are in single pairs, oblong or lanceolate in shape, with a three-parted tendril between them. The flowers, which are solitary, may be bluish, or they may be white. The plant may grow to a height of about 3 feet, obtaining support by its tendrils. The fruit is a small, smooth-winged, several-seeded pod. The seeds vary in colour and size, but all have the characteristic wedged, angled, or hatchet-shaped appearance.

The seeds vary much in colour, but all are actually poisonous. The vetch seed differs from the pea in being flattened on each side, so that a section would be triangular.

The locality from which the seed is imported makes no difference whatever, it is poisonous under all circumstances as an ingredient in horse-food.

The following table records the colours of certain samples examined by Prof. Harz :—

Locality.	Colour of Seeds.
Unknown	... Greenish-yellow.
,, ...	... Reddish-yellow.
Austria	... Yellowish-green.
Bohemia	... Reddish pea-coloured.
Greece	... Partly faint pea and partly brown.
Sicily	... Pea-coloured and spotted.
,, ...	... Pale pea-coloured.
Verona	... Pea-coloured.
East India	... Dark marbled on a brownish ground.
,, ...	... Deep reddish-brown, spotted black.

Mr. Church in his treatise on the "Food-Grains of India," gives the following analysis of the Indian variety :—

Water	10·1
Albuminoids	31·9
Starch and fibre	53·9
Oil	0·9
Ash	3·2

The nutrient ratio is 1 : 1·75, the characteristic feature being its richness in nitrogenous constituents.

In the case of human beings paralysis of the lower extremities is the result of using the pulse as a daily article of food. The attack is sudden and the paralysis is incurable.*

A typical instance showing the effects on horses was reported by Messrs. Leather, of Liverpool, in 1884, where in a stud of 74 cart-horses, 35 became ill as a result of Indian *mutters* being mixed with their food to the extent of 3 or 4 pounds per day. Of the 35, 19 died, 2 were killed as useless, and 14 recovered. The symptoms, as described by Messrs. Leather, were as follows:—Sometimes the horses said to be affected seemed, when at rest, in perfect health, but on being exercised, particularly if the weather was cold, they were seized with dyspnœa and roaring, some dying from asphyxia, others getting relief when tracheotomy had been performed.

In the Bristol Tramways Company's case, 123 horses out of a stud of 800 fell ill owing to feeding on *Lathyrus sativus*. "A horse being exercised was taken suddenly ill; it roared, its flanks heaved, its mouth was kept wide open, the nostrils were distended and the tongue hung out and became livid; it stared and staggered, and threatened every moment to fall down strangulated or suffocated, and during this paroxysm, which lasted several minutes, the perspiration ran freely off every part of the horse."

As with man, so with horses, *Lathyrus* is a cumulative poison, the symptoms of poisoning showing themselves the sooner, the greater the proportion of *Lathyrus sativus* seeds in the horses' food.

Great mischief has resulted from horses eating of the vetch seeds, as shown by the following list:—Great Western Colliery Company, 24 horses died; Bristol Tramway Company, several horses died; Messrs. Leather, Liverpool, several horses died; and an outbreak among horses at Newcastle-upon-Tyne. It is very doubtful if a horse once affected ever regains health.

The following paper by Mr. F. G. MEACHEM on "Horse-feed" was taken as read:—

* *Trans. Botanical Society, Edinburgh*, 1894-95, vol. xx., page 305.

HORSE-FEED.

By F. G. MEACHEM.

During the last few years the writer has collected information as to various horse-feeds, especially at collieries, and he hopes that this paper may be of service to the members. He will be glad to receive information from any member for publication in the *Transactions*, so that the information may extend and embrace all the coal-fields of the United Kingdom. The table is arranged under the headings :—(1) Thin coal-seam pits, including Cannock Chase, part of Warwickshire, Bilston district, etc. ; (2) thick coal-seam, as worked not less than 20 feet thick in the South Staffordshire coal-field alone, and horses 14½ hands in height.

The average weight of a 14½ hands pit-horse is 970 pounds, and of a 12½ hands pony, suitable for work in thin seams, 670 pounds. Bearing in mind the facts and also the accepted opinion that horses eat in direct proportion to the work done by them, it will be seen that there is great variations in the weekly cost of food, but this may be accounted for by the work done. In Nos. 3 and 7 collieries, working about two days per week, it appears to be a case of, if there is no work there is no meat. At the same time the feed supplied is well calculated to sustain the horses, and by increasing the weight they would do six days at the least possible cost.

Maize is omitted from the model feed, as it is too heating, especially for horses working in a mine. Prof. Wrightson's table of the composition of foods shows that maize contains 6·5 per cent. of fats, four times the amount contained in beans and three times that of peas. Maize will maintain a moderate amount of work, but alone it is unable to supply the necessary materials for hard work. An ample allowance of albuminoid food is required, in this maize is deficient. It only contains about 10 per cent., whilst beans contains 25·5, and peas 22·4 per cent.

The following table shows the costs of horse-keeping :—

No. of Collieries.	Average Size of Horses.	Weight of Feed.								Total Weight per Day.	Cost per Week.	Remarks.
		Oats.	Peas.	Bran.	Straw.	Beans.	Hay.	Barley.	Maize			
	Hands.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	s. d.	
	THIN COAL-SEAM PITS.											
1	13	—	†	†	—	—	†	—	†	—	8/6	
2	13	—	—	—	—	—	—	—	—	—	7/	
3	13¼	—	1·20	4·00	2·66	1·20	9·33	1·43	1·43	21·25	5/1¾	Two days worked per week.
4	13 to 16	—	—	—	—	—	—		—	—	7/5	
5	12½ to 15	—	—	—	—	—	—	—	—	—	8/3	
6	14	—	—	—	—	—	—	—	—	—	7/6	
7	13½	—	1¼	4	2½	1¼	9½	1½	1½	21½	4/7½	Two days worked per week.
8	14½	12	—	4	—	—	12	—	—	28	8/6 to 9/1	
9	13½	1·28	—	7·13	—	2·13	11	—	—	21·54	8/ to 9/	
	THICK COAL-SEAM PITS.											
10	14¼	—	—	9½	—	3½	16	—	—	29	8/6	
11	—	—	—	—	—	—	—	—	—	—	9/2	
12	14½	—	—	—	—	—	—	—	—	—*	7/1	
13	14½	11	—	4	—	—	12	—	—	26	7/9	
14	14½	1¾	—	10	6¼	3	14½	—	2¾	38¼	10/2	Heavy gradients in the mine.
	SURFACE HORSES.											
15	—	—	—	—	—	—	16	—	18	34	9/4	Canal-boat horses.
16	—	14	—	6	—	—	10	—	—	30	9/4	
17	—	12	—	—	—	—	—	—	—	—	10/	
18	—	13	—	—	—	—	20	—	—	33	8/	
19	—	16	—	—	2½	—	7½	—	—	26	6/5	London General Omnibus Co.
20	—	15	—	—	15	9½	9	—	—	48	11/1	
21	—	8	—	—	—	—	20	2	—	30	7/4	

The following model daily feeds for horses are suggested by the writer :—

Food.	Thin Coal-seam.		Thick Coal-seam.	
	Weight.	Cost per Week.	Weight.	Cost per Week.
	lbs.		lbs.	
Oats	3		5	
Peas	3		3	
Beans	2		4	
Total	8		12	
Chaff, hay, and straw...	12		10	
Bran	4		6	
Grand total ...	24	7s.	28	8s.

† Quantity not stated.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,

OCTOBER 12TH, 1895.

MR. A. L. STEAVENSON, PAST-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on September 28th and that day.

The proceedings of the Council of The Federated Institution of Mining Engineers were reported.

AWARDS FOR PAPERS.

The SECRETARY read the following list of papers read during the year 1894-95, for which prizes have been awarded by the Council to the authors :—

"Sinking with Rock-drills." By Mr. Frank Coulson.

"The Effect of an Obstruction in the Air-way of a Mine." By Mr. T. L. Elwen.

"Magnetic Declination in Mines." By Mr. James Henderson.

"The Working of Hæmatite in the Whitehaven District." By Mr. J. M. Main.

"The Mining of the Softer Ores of Furness." By Mr. H. Mellon.

"Improvements in Brick-kilns." By Mr. R. W. Moore.

"The Extension of the Cumberland Coal-field, Southward and Northward under the St. Bees Sandstone." By Mr. R. Russell.

"Electric Transmission of Power." By Mr. Alexander Siemens.

"Saving of Life from After-damp, Smoke, or Fumes in Mines." By Mr. Simon Tate.

"Engineering Heliography, or the Sun-print Copying of Engineering Drawings." By Mr. B. H. Thwaite.

"British Guiana Gold-fields." By Mr. E. P. Wood.

"The Murton Coal-washer." By Mr. W. O. Wood.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. CARL ANDERSEN, Mining and Metallurgical Engineer, Mogollon, New Mexico, U.S.A.

Mr. W. J. ARMSTRONG, Mining Engineer, c/o Mr. D. Rowe, Ferreira Gold Mining Co., Johannesburg, Transvaal, S.A.R.

Mr. WILLIAM BLAKEMORE, Mining Engineer, Glace Bay, Cape Breton, Canada.

Mr. FREDERICK GROENDYCKE BULKLEY, Mining Engineer and Mine Operator, Denver, Colorado, U.S.A.

Mr. HENRY SAMUEL DENNY, Mining Engineer, c/o the D. D. Banket Gold Mining Co., Ltd., Maritzburg, Natal.

Mr. W. MARTIN EPTON, Engineer, The Village Main Reef Gold Mining Co., Ltd., Mine Office, P.O. Box 737, Johannesburg.

Mr. EDWARD WILLIAM HAWKER, Metallurgist and Assayer, Adelaide Club, Adelaide, South Australia.

Mr. R. SPENCER HAWKINS, Mining Engineer, Ayrshire Mine, Lo Mogunda, Salisbury, Mashonaland, South Africa.

Mr. SEPTIMUS HESLOP, Manager, New Beerbhoom Coal Co., Ltd., Asansol, Bengal, India.

Mr. CHARLES EDWARD HOGG, Civil Engineer, No. 1, St. Helen's Place, London, E.C.

Mr. CHARLES KAUFMAN, Mining Engineer, St. George's Terrace, Perth, Western Australia.

Mr. H. K. LANDIS, Mining Engineer and Metallurgist, 253, Broadway, P.O. Box 1833, New York, U.S.A.

Mr. JOHN LASSEY, Civil and Mining Engineer, Certificated Colliery Manager, Surveyor and Valuer, Westminster Road, Liverpool.

Mr. DAVID MACKEEN, General Manager, Dominion Coal Co., Ltd., Glace Bay, Cape Breton, Canada.

Mr. JAMES MACKINTOSH, Mechanical and Mining Engineer, Raneegunge, India, and Lamancha, Peebleshire, Scotland.

Mr. RALPH MARTIN, Manager, Cardigan Stone Co., Ltd., Llandyssil, South Wales.

Mr. CHARLES ATKINSON MOLSON, Mining Engineer, c/o the Elkhorn Mining Co., Ltd., Elkhorn, Jefferson Co., Montana, U.S.A.

Mr. GILES OTIS PEARCE, Assayer, Mineralogist, and Chemist, 708, Colorado Avenue, Colorado City, Colorado, U.S.A.

Mr. ROBERT ROBERTS, Manager, Oakeley Slate Quarries Co., Ltd., Blaenau Ffestiniog, North Wales.

Mr. SAMUEL M. ROBINS, Superintendent, The New Vancouver Coal Mining and Land Co., Ltd., Nanaimo, British Columbia.

Mr. WILLIAM HENRY SEAMON, Professor of Chemistry and Metallurgy, and Director of the New Mexico School of Mines, Socorro, New Mexico, U.S.A.

Mr. THOMAS FREDERICK VEASEY, Civil and Mechanical Engineer, 5, Copthall Buildings, London, E.C.

Mr. GARDNER F. WILLIAMS, General Manager, De Beers Consolidated Mines, Ltd., Kimberley, South Africa.

Mr. H. J. CARNEGIE WILLIAMS, General Manager, Philippines Mineral Syndicate, Ltd., c/o Hong Kong and Shanghai Banking Corporation, Manila, Philippine Islands.

Mr. JOSEPH R. WILSON, Manufacturer and Mechanical Engineer, 1001, Chestnut Street, Philadelphia, U.S.A.

Mr. THOMAS TRAFFORD WYNNE, Mining Engineer, The Burma Ruby Mines, Kyatpyin, Upper Burma.

ASSOCIATE MEMBERS—

Mr. M. J. MORPURGO, Georgetown, Demerara, British Guiana.

Mr. R. T. SCHRÄUBSTADTER, San Luis de la Paz, Gto, Mexico.

Mr. EDWARD G. STOIBER, Mine Owner, P.O. Box 129, Silverton, Colorado, U.S.A.

ASSOCIATE—

Mr. ROBERT ROBSON, Overman, 2, Thornley Terrace, Tow Law, R.S.O., Co. Durham.

STUDENT—

Mr. WALKER OSWALD TATE, Mining Student, Trimdon Grange.

CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, IPSWICH, 1895.

The report of the proceedings of the Corresponding Societies Committee of the British Association was read, and of Mr. J. H. Merivale, the delegate representing the Institute, as follows :—

TOGSTON HALL, NORTHUMBERLAND,
OCTOBER 1ST, 1895.

TO THE PRESIDENT AND COUNCIL OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENTLEMEN,

I attended the conference of delegates of the corresponding societies, at the meeting of the British Association for the Advancement of Science held in September, 1895, at Ipswich.

The committee, as you are aware, have declined to receive delegates from some of the societies forming The Federated Institution of Mining Engineers on the ground that they print no *Transactions* and undertake no independent original work, that everything they do is done through The Federated Institution of Mining Engineers whose delegate, therefore, represents each and all of the federated institutes. I pointed out that independent original work was done from time to time by individual institutes, that some of these institutes were very large and important, that they were scattered over Great Britain, and that it appeared to be a mistake for the committee not to encourage as many societies as possible to send delegates and take an interest in the furtherance of scientific work. The committee sympathized with my views, and will reconsider the question.

Suffolk is an agricultural county and several of the most important papers were upon farming. In these days when many coal-owners are also of necessity farmers, it cannot be said that this subject is not of more than general interest to the members of the Institute; but, as in the past, I propose to confine my remarks to the papers and reports bearing more directly upon mining.

There were several papers upon the old rocks underground in south-eastern England. In the first place, Mr. W. Whitaker, the President of the Geological Section, devoted a considerable portion of his address to the prospects of finding coal beneath the newer rocks in the south-east of England; and gave in an appendix a list of the chief papers upon the subject published since 1889. He said that accounts had been published of ten deep borings reaching to the older rocks of the London basin. In four of these (Meux, Streatham, Richmond, and Dover) Jurassic beds separate those rocks from the Cretaceous beds; and there are six in which these last rest directly on older rocks (Ware, Cheshunt, Kentish Town, Crossness, Culford, and Harwich; and Stutton, of course, makes a seventh). The Jurassic rocks occur only in the southern borings, either in London or still further southward, and in one case only (Dover) is there any considerable thickness of these; in the other three they are from 38½ to 87½ feet thick. So far as regards Suffolk and its borders we may therefore disregard them, except in the far west, near their outcrop, and we may pass on to consider the older rocks that have been found. So far the occurrence, next beneath the Cretaceous or Jurassic beds, of Silurian, Devonian, and Carboniferous rocks has been proved, whilst in some cases we are still doubtful as to the age of the old rocks found. In five cases, distinctive fossils have been found (Ware, Cheshunt, Meux, Dover, and Harwich), but in five others they have not (Kentish Town, Crossness, Richmond, Streatham, and Culford) and it is in the latter group, too, that the character of the beds leaves their age in doubt. So far another must be added to these, as no fossil has yet been found in the old rocks at Stutton. Of the ten deep borings in the London basin (using the term in the widest sense, as including the Chalk tract that everywhere surrounds the Tertiary beds), nine are due to endeavours to get water from deep-seated rocks, and in addition to these nine we have several other deep borings, which, though not carried through to the base of the Secondary rocks, yet give us much information concerning those beds (at Holkham, Norwich, Combs, Winkfield, London, Loughton, Chatham, and Dover). In one case only, that of Dover, has the work been done for the purpose of exploration, but now, after a few years' interval, a second trial has been made at Stutton. Both of these borings were started for a much more definite object than merely to prove the depth to older rocks, or the thickness of the Cretaceous and Jurassic series. The first place to suggest itself to those geologists who had worked at this question, as a good site for trial, was the neighbourhood of Dover, and for various good reasons. The trial has been made, and successfully, several hundred feet of Coal-measures having been found, without reaching their base, but with several beds of workable coal. Beyond that neighbourhood, however, geologists are not in such accord, and, generally speaking, fairly good reasons can be given both for and against the selection of many tracts for trial, except in and near London, where no geologists would recommend it, from the evidence in our hands. Let us then shortly review the evidence that we have on the underground extension of the older rocks in south-eastern England, with a view of considering the question of the possibility of finding Coal-measures in any of the folds into which those rocks have probably, nay, almost certainly, been thrown. The area, within which the borings that reached older rocks in the London basin are enclosed, is an irregular pentagon, from near Dover, on the south-east, to Richmond

on the west, thence to Ware, thence to Culford on the north, thence to Harwich, and thence southward to Dover, the greatest distance between any two borings being from Dover to Culford, about 86 miles. It is therefore over a large tract, extending of course beyond the boundaries sketched above, that we have good reason to infer that older rocks are within reasonable distance of the surface, nowhere probably as much as 1,600 feet, and mostly a good deal less. We must now consider some evidence outside the tract hitherto dealt with. Southward of the central and eastern parts of the London basin we have evidence that the Lower Cretaceous beds thicken greatly, from what is seen over their broad outcrop between the North and South Downs. We know also, from the Dover and Chatham borings, that the Upper and Middle Jurassic beds come in to the south-east, whilst the Sub-Wealden exploration, near Battle, proved that those divisions thicken greatly southward, the latter not having been bottomed at the depth of over 1,900 feet, at that trial-boring. Westward, however, near Burford in Oxfordshire, and some miles northward of the nearest part of the London basin, Carboniferous rocks have been found at the depth of about 1,180 feet, these being separated from the thick Jurassic beds (including therein the Liassic and Rhætic) by perhaps 420 feet of Trias. They consist of Coal-measures, which were pierced to the depth of about 230 feet. In and near Northampton, north-eastward of the last site, and still further from the northern edge of the London basin, the like occurs; but the beds found are older than the Coal-measures, and the Trias is thin, not reaching indeed to 90 feet in thickness, and being absent in one case. At one place, too, the Carboniferous beds have been pierced through, with a thickness of only 222 feet, when Old Red Sandstone was found, and in another place still older rock seems to have been found next beneath the Trias. The depth to the rocks older than the Trias, where they were reached, was 677, 738, and 790 feet, or 395, 460, and 316 feet respectively below sea-level. Some of these figures must be taken as somewhat approximate, though they are near enough to the truth for practical purposes. A boring at Bletchley, to the south, reached granite rocks at the depths of 378½ and 401 feet; but these rocks seem to be only boulders in the Jurassic clay; their occurrence, however, is suggestive of the presence of older rocks at the surface in Middle Jurassic times. Much further northward, at Scarle, south-west of Lincoln, the older rocks have been reached at the depth of about 1,500 feet, all but 141 of which are Trias, and they begin with the Permian (which crops out some 18 miles westward), the Carboniferous occurring after another 400 feet, and having been pierced to 130 feet. We, have then, evidence that over a large part of south-eastern England, reaching northward and westward of the London basin, though the older rocks are hidden by a thick mantle of Jurassic, Cretaceous, and Tertiary beds, yet they seem to be rarely at a depth that would be called very great by the coal-miner. They are distinctly within workable depths wherever they have been reached. There is no area of old rocks at the surface in our island, south of the Forth, in which Coal-measures are not a constituent formation. Further north, in the great tract of central and northern Scotland, there are no Carboniferous rocks, but we can hardly say that none ever occurred, at all events in the more southern parts. We know, however, that on the west and north, Jurassic and Triassic beds rest on formations older than the Carboniferous. It is not, however, to this more northern and distant tract that we should look for analogy to our underground plain of old rocks; rather should we look to more southern parts, to Wales and to central and northern England, where Coal-measures are of frequent occurrence. On the principle of reasoning from the known to the unknown, Mr. Whitaker could not see why we should expect anything but a like occurrence of Coal-measures, in detached basins, in our vast underground tract of old rocks. What, then, is the evident conclusion from what we know and from

what we may reasonably infer? Surely that trials should be made to see if such hidden coal-basins can be found. One trial has been made, and it has succeeded: the Dover boring has proved the presence of coal underground in eastern Kent, along the line between the coal-fields of South Wales and of Bristol on the west, and those of Northern France and of Belgium on the east. The long gap between the distant outcrops of the Coal-measures near Bristol and Calais has been lessened very slightly by the working of coal under the Triassic and Jurassic beds near the former place, but much more by our brethren across the Channel, the extent of the Coal-measures beneath the Jurassic and Cretaceous beds, having not only been proved by the French and the Belgians along their borders, but the coal has been largely worked. But is this the only line along which we are to search? Are we to conclude that the only coal-fields under our great tract of Cretaceous beds (where these are either at the surface or covered by Tertiary beds) are in Kent, Surrey, and other counties to the west? Have we no coal-fields but those of Bristol and South Wales? The bounds of our Midland and northern coal-fields have been extended by exploration beneath the New Red series; are we to stop here and assume that there can be no further underground extension of the Coal-measures south-eastward?

Mr. W. Whitaker also read a paper upon the "Trial Boring at Stutton," which is the first attempt made by the Eastern Counties Coal-boring Association. It is situated in low-lying ground southward of Crepping hall, and has been successful in reaching the base of the Cretaceous beds at the depth of 994 feet, and in proving that these are at once underlain by much older rocks. The question now is, what are these older rocks? and upon this point Mr. Whitaker reserves his opinion for the present.

Mr. Joseph Francis read a paper on "The Dip of the Underground Palæozoic Rocks at Ware and Cheshunt," in which he called attention to the fact that some geologists interested in ascertaining the lie of the ancient rocks beneath the eastern counties are doubtful whether reliance can be placed upon statements that have been made with regard to the dip of the rocks found in the deep borings at Ware and Cheshunt. These borings were undertaken by the New River Company with the object of procuring water from the Lower Greensand, but on reaching certain depths it was seen to be hopeless to expect water from below the Gault. Orders were about to be given for a cessation of the work, when a wish was expressed by certain geologists that endeavours might be made to learn the direction of the dip of the lowest stratum reached in each case. The New River Company thereupon gave instructions for the necessary investigation to be made at their expense. A number of scientific men formed themselves into a committee to arrange the modes of procedure, and, under their advice, the various experiments were carried out. Before the year 1872, a deep well and boring had been formed at Turnford. In 1874, arrangements were made for deepening this bore, and an iron tube, 24 inches in diameter, and nearly 1,000 feet in length, was provided for conveying the expected supply of water to the surface. For some time the hole was sunk by the old system of boring with chisels, but in 1878 the method of boring by means of diamonds had been perfected, and it was then decided to obtain an early solution of the question by drilling, in this more expeditious way, a hole at Ware, six miles north of Turnford. In the end, however, the Gault was pierced through at both places at about the same time. The various appliances, magnetic or mechanical, either suggested or used for obtaining the directions of the dip of the beds, were described and illustrated by diagrams. At Ware, at a depth of 828 feet below the surface, and 31 feet below the top of the stratum, the Silurian

rocks dip at an angle of 41 degs. and towards south 1 deg. west. At Turnford, at a depth of 994 feet below the surface, and 14 feet below the top of the stratum, the Devonian rocks dip at an angle of 25 degs., and south 17 degs. west. At both places, the ancient rocks dip in directions lying between south and south-south-west, and by placing on a geological map of the south-eastern portion of England lines to show the ascertained bearings, it is demonstrated that the greatest inclinations of the strata are, roughly speaking, at right-angles to the directions of the chief axes of the Weald.

Mr. F. W. Harmer read a paper on "The Importance of Extending the Work of the Geological Survey of Great Britain to the Investigation of the Deep-seated Rocks by Means of Boring," in which he said that systematic exploration of the subterranean geology of these islands was equally important from a scientific and a practical point of view. At present the knowledge of the structure of the rocks, the author pointed out, is due either to isolated and occasional borings, such as that of the Ipswich Syndicate in search of coal, or to deep wells sunk by mercantile firms, but the latter do not reach further than is necessary to obtain a supply of water, and the work is generally suspended just where it becomes geologically most interesting. But such a survey is important, because unsuspected sources of wealth may be hidden under our very feet. It is a mistake to suppose that a discovery such as that of a new coal-field would enrich only the landowners of the district, because whenever any appreciation of real property takes place the State at once claims its share of the increased value, both for imperial and local purposes.

Mr. Garwood communicated a paper on "The Zonal Divisions of the Carboniferous System," in which he called attention to previous attempts which had been made to divide the Carboniferous rocks into zones, noting the zonal divisions of the Carboniferous rocks of the North of England, established by Messrs. De Koninck and Lohest, and the view expressed by Prof. Waagen that fuller work would enable geologists to define a series of zones in the Carboniferous as in older and newer strata.

The "Report of the Committee on the Circulation of Underground Waters" contained a digest of the previous twenty years' reports. It appears desirable, to the committee, that the Corresponding Societies should annually send the details of sections, etc., to the offices of the Geological Survey of the United Kingdom, Jermyn Street, London. The general results are as follows:—(1) The source of all water supply, whether from streams, wells or natural springs, is the rainfall falling on the area, or that adjacent to it. (2) The quantity of water to be obtained under all three heads is that annually falling, less the quantity evaporated, and less natural loss through retention after natural filtration. (3) The quantity of underground water to be obtained from sandstones and grits is governed by the cubic content of the interspaces between the grains; the larger the spaces, the greater the facility for the storage and passage of water. (4) In calcareous rocks, such as Carboniferous and Magnesian Limestones, Oolitic calcareous rocks, and chalk, the grains are exceedingly small, the spaces almost microscopic, and the passage of water through the rock exceedingly slow, but waters so passed are naturally and effectually filtered. In rocks of this class, however, open spaces, following lines of joint, faults, and other planes of weakness constitute fissures and caverns, through which water flows freely in defined channels, as on the surface, and is not subject to natural filtration like it, and has not the advantage of the purifying effect of sunlight on the passage. (5) When porous rocks of different characters are separated by thin beds of impermeable material,

it is often possible to obtain several classes of water from one well, suitable unsuitable, as the case may be, for the brewing of ale or stout, the dilution spirits, or the exigencies of the wool or the indigo-dying trades. (6) Where are pumped at the same daily rate without abstracting what the late Mr. Hawk called "water of cistonage," the hardness is reduced after a year's pumping, and remains stationary over proved periods of forty years. If the pumps are lowe and the apex of the inverted cone be placed still deeper beneath the mean level, the width of the base of the cone is extended, and a new concentric ci of supply is added to the contribution ground, and the water hardens for a ti but after the soluble salts have been pumped out the degree of hardness rema constant as before. (7) Faults in porous rocks of whatever thickness, wh were originally overlain by porous rocks, no matter how great their throw may are no obstacles to the passage of underground water. (8) Where the same or have been before subsequent denudation, overlain by impermeable mate the fissure of the fault is filled with impermeable material, and it forms a nat puddle-trench separating the district into distinct water-tight zones. (9) W faults of the latter class exit, and the area on one side of the fault margins the and a quantity of water is annually abstracted, exceeding the quantity abso by rainfall, the excess is derived from the sea, a reversal of the undergro current taking place, and as this goes on the rock becomes surcharged with sa and can no longer act as a filtering medium, and the water pumped daily appr mates more and more to the sea-water from which it is derived. (10) Engin and architects, in many cases, do not realize the danger of placing public pump stations where the area of supply includes sewage-farms and objectionable t refuse. It is exceedingly desirable that the officials of the Local Govern Board should have their attention strongly drawn to this important matter.

There were several papers and reports upon the subject of earthquakes earth-tremors, contributed by Prof. Milne and Mr. Symons. This matter may h a bearing upon the issue of gas in mines; and, now that the experiments u explosives are completed, it might be a fitting subject for examination by Institute. The committee are at present experimenting at two stations. under the charge of Mr. C. Davison at Birmingham, and the other at the Isl Wight in charge of Prof. Milne.

The report of the committee on underground temperature compared the det of observation made in a deep bore-hole at Cremorne, near Sydney, New So Wales. The bore-hole was 2,929 feet deep, and the temperature at a depth 2,733 feet from the surface was 97 degs. Fahr. The mean surface-temperature 63 degs., which gives an increase at the rate of 1 deg. Fahr. for every 80 feet of dept

One of the excursions was made to the Brandon flint-mines. In addition to t present working-pits, there are several ancient abandoned mines, which were work in neolithic times, and some of them have been opened out, and explored Canon Greenwell. There is reason to believe that flint has been mined continuous at Brandon since the neolithic age. A full account of these very interesti mines is published in a memoir† of the Geological survey.

Yours faithfully,

JOHN H. MERIVALE.

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* *Trans. Fed. Inst.*, vol. vii., page 726.

† "The Manufacture of Gun-flints, the Methods of Excavating for Flint. th Age of Palæolithic Man, and the Connexion between Neolithic Art and the Gun flint Trade." By Mr. S. B. J. Skertchly.

DISCUSSION UPON THE "REPORT OF THE PROCEEDINGS OF THE EXPLOSIVES COMMITTEE"* AND UPON MR. WINKHAUS' PAPER ON "EXPERIMENTS WITH EXPLOSIVES."†

Mr. J. L. HEDLEY (H.M. Inspector of Mines) said in view of the fact that several communications had been made by members of the Institute as part of the discussion on the report of the Explosives Committee, it was desirable that he should make one or two remarks, although some of them might be reiteration.

The Coal Mines Regulation Act of 1887 provided that, under certain circumstances, an explosive should be used that could not ignite gas or coal-dust, and the Committee was formed with a view of finding out whether there was such an explosive in the market. The first part of the *Report* of the Committee was now before the members, and dealt with the question of gas. One point which had been referred to by those who had taken part in the discussions was with regard to the small weight of explosives used in the experiments, and the Committee were told that the quantities were such as were not used in coal-mines, and also that the sizes of cartridges were not the same as those used in mines. But when they considered that in some mines charges of blasting-powder of only 3 ounces were being used, it must occur to the members that with the higher explosives, for which the manufacturers claimed so much greater strength, they must use considerably smaller quantities than 3 ounces, and he was not going too far when he said that, taking the equivalent force of some of the explosives, as compared with blasting-powder, the charges used in the experiments were not smaller than would actually be used in the mines.

Cartridges of the higher explosives had been received at their Hebburn station from collieries in the district, of the same diameter as the bore of the cannon with which the experiments were made. If the explosive, when made up in cartridges of the same diameter as the bore of the cannon, was said to be unsafe, it clearly pointed to the conclusion that the explosive was not a safe one for use in coal-mines. One speaker suggested that a certain weight of an explosive must be used to ensure safety, but such a condition did not meet the requirements of

* *Trans. Fed. Inst.*, vol. viii., pages 227 and 593; vol. ix., pages 115, 206, and 274; and vol. x., page 38.

† *Ibid.*, vol. ix., pages 250 and 274.

mining. Where weights of 2 to 30 ounces might be required to effe desired work, it followed as a matter of course that such an exp could not be used with efficiency in the mine. The question c blasting efficiency of explosives had been tested in Trauzl leaden b and in all cases the explosive had been analysed, and, further, had tried in actual work at a colliery.

The chief point, however, referred to the Committee was the qu of safety explosives that could not ignite gas. The experiment not been made under conditions favourable to any explosive as such ditions might not always be carried out by the workmen. The Comm did not desire to show that under certain favourable conditions a explosive would not ignite gas or coal-dust; but rather to ascert an explosive would ignite gas or coal-dust, or a mixture of both, conditions which might and sometimes did exist, in a mine.

Accidents had happened from a charge exploding when it was s placed in the shot-hole, a state of things which was demonstrated l Committee's experiments, with unstemmed shots. Experiments made in which stemming was used, of varying lengths, as accident happened in mines where short lengths of stemming had been blow and similar results were obtained.

Mr. John House had made an interesting communication,* for w he deserved every credit, as he seemed to have thoroughly studie matter. Mr. House supported most of the conclusions arrived a the Committee, he mentioned certain essential conditions which c to be fulfilled by a safety-explosive, and all those who had rea remarks would support the conditions suggested by Mr. House.

A supplementary *Report* had been issued containing the resu experiments with westfalit. The results had been very much crit by certain persons who were interested in that explosive, and it was fair to state that they disputed the genuineness of the explosive u at the same time he might say that the explosive with which the e ments had been made was obtained from Germany, and taken fr packet marked or labelled "westfalit," "made in Germany."

Dr. C. Le Neve Foster wrote that he had recently ha opportunity of inspecting the experimental gallery at the Consolid colliery near Gelensenkirchen, but unfortunately no experiments were made at the time of his visit. It was evident from an inspection c experimental plant that the trials had been made with great

* *Trans. Fed. Inst.*, vol. ix., page 206.

indeed, that fact was palpable from the perusal of Mr. Winkhaus' paper. One point was brought out very clearly from the valuable experiments, viz., that the probability of a fiery atmosphere being ignited by a shot depended not only upon the composition of the explosive, but also upon the weight of the charge fired. This itself was a reason for paying special attention to Mr. Winkhaus' results, which were obtained with charges varying from $1\frac{3}{4}$ to 21 ounces (50 to 600 grammes).

The Royal Commissioners on Explosions from Coal-dust in Mines * stated "We have come to the conclusion that, whatever minor objections may be established against the use of high explosives, their general employment would greatly limit the risk of explosion in dry and dusty, and in fiery mines," and this may be construed as an invitation to use dynamite and its congeners in place of blasting-powder. Mr. Winkhaus, on the other hand, showed that charges of $3\frac{1}{2}$ to $5\frac{1}{4}$ ounces of dynamite and gelatine-dynamite almost invariably sufficed to ignite a dusty atmosphere containing no fire-damp. It is true that his experiments were made with unstemmed shots, and we may expect that his further trials with stemming will show that the reduction in temperature of the escaping gases, due to the extra work which has to be performed, will render given charges less likely to ignite dangerous atmospheres.

Mr. Winkhaus' experiments confirmed those of Mr. Lohmann as to the danger of dynamite, which had been likewise deduced by the French Fire-damp Commission from purely theoretical reasoning. As is known to many of the members, explosives used in fiery mines in France must satisfy certain conditions amongst which are :—(1) The products of their detonation must not contain any combustible element, and (2) their temperature of detonation must in no case exceed 1,900 degs. Cent.† for explosives used in stone-work, nor 1,500 degs. Cent. for those employed in coal-getting. The use of dynamite in coal-mines in France has long been forbidden, as its calculated temperature of detonation is 2,900 degs. Cent. The French manufacturer, in supplying explosives, is required to state the temperature at which they detonate, and the paper envelope of each cartridge has the chemical composition of the explosive printed upon it.‡ This example might be followed with advantage in this country, and the mine manager would then know precisely what he was using.

* *Final Report*, page xxvii.

† *Report of the French Commission on the Use of Explosives in the Presence of Fire-damp in Mines*, page 162. Translated by Messrs. W. J. Bird and M. Walton Brown.

‡ *Ibid.*, pages 159 and 162.

A question had been asked as to the fineness of the coal-dust used in Mr. Winkhaus' experiments. He might mention as a proof of its fineness that he saw a shovelful of it thrown up into the air, and the particles formed a black cloud which floated about.

The Government of Saxony had recently (July 18th, 1895) published the following regulations in place of those of 1890:—

A. No blasting may be carried on in coal-mines without the permission of the mining authorities (*Bergamt*). In workings carried on in coal-seams or in strata rich in coal, no blasting is permitted unless:

(1) Coal-dust is not present, owing to the damp condition of the workings; or

(2) Before a shot is fired, the coal-dust has been rendered harmless by copious watering for a distance of at least 33 feet (10 metres) from the shot; or

(3) A method of blasting is employed which will certainly prevent the formation of any flame.

B. When blasting is permissible under clause A, it must be carried out in obedience with the instructions of the manager or under-manager (*Obersteiger*), and in accordance with the following precautions:—

(1) Shot-holes shall be so bored, charged, and stemmed that a blowing-out of the stemming shall be, as far as possible, prevented.

(2) All charges must be stemmed.

(3) Only one shot must be fired at a time, but several shots fired simultaneously by electricity are reckoned as one shot.

(4) In the case of clause A (3), the coal-dust must be moistened for a distance of 3 to 6 feet (1 to 2 metres) from the shot.

(5) As soon as a shot has been ignited, the workmen must retire to a prearranged place of safety, at least, if it be in any way possible, 165 feet (50 metres) from the shot, and preferably in some branch level and behind a closed partition or screen.

(6) After the firing of each shot, and before any further blasting takes place, the working-place and its vicinity must be examined for coal-dust for a distance of at least 33 feet (10 metres) from the face, by some person appointed by the manager or under-manager.

C. If, after firing a shot, it be noticed that, in spite of employing the precautions enumerated under clauses A and B, the explosion was strikingly louder than usual under similar circumstances, and if in consequence or from other appearances it is concluded that the coal-dust had been ignited, blasting at that working-place must be stopped until further notice, and the occurrence has been notified to the inspector of mines.

D. The mining authorities (*Bergamt*) may require special regulations to be established for carrying on blasting in coal-mines which are not classed as fiery mines, but in which there is coal-dust of a specially dangerous nature.

The CHAIRMAN said the only difficulty he had experienced in the matter of high explosives was that he could not get the workmen to use them, unless the explosives were provided free of cost, and the shots were put into the holes and fired for them. Safety-explosives were introduced with the view of preventing accidents and for the protection of the workmen's lives, but they seemed to consider that the owners were reaping some

benefit and trying to take advantage of them. He was of opinion that all experiments with safety-explosives should be made by independent engineers, and the explosives should be provided by the persons appointed to make the tests, and not by the proprietor of one of the explosives being tested.

Mr. J. L. HEDLEY said with regard to the marking of cartridges, that the Explosives Committee had come to the conclusion that the composition of explosives were varied from time to time, and they were supported in this view by several gentlemen who had taken part in the discussions. In consequence, the Committee made the suggestion that every packet should be marked with the ingredients composing the particular explosive. Dr. Foster's remarks supported this view, and it was important that it should be adopted if possible, so that persons using the explosive might know from time to time that they were using an explosive of the same composition.

Mr. A. C. KAYLL said that nitrate-of-ammonium explosives were so similar in colour that it was very important that each cartridge should bear the name of the explosive upon the cover. The makers of roburite, carbonite, and ardeer powder had adopted this suggestion, but it was equally desirable that the constituents of the explosive and the date of its manufacture should be marked upon each 5 lbs. packet and upon the cover of each cartridge.

The following paper was taken as read :—"The Whitehaven Sandstone Series," by Mr. J. D. Kendall :—

THE WHITEHAVEN SANDSTONE SERIES.

By J. D. KENDALL.

In the cliffs along the coast near Whitehaven, occurring interruptedly over the prolific Coal-measures, there is a purple-grey arenaceous rock known to geologists as the Whitehaven Sandstone. It is there, at least, 170 feet thick. The same rock, or rock of the same general character, also occurs over other parts of the coal-field, being sometimes interbedded to a considerable extent with shale, and attaining then an aggregate thickness of 500 or 600 feet. It is therefore convenient to include the whole of these rocks under the name of the "Whitehaven Sandstone Series."

The earliest notice of these rocks, with which the writer is acquainted, is a paper by Prof. Sedgwick read in 1832.*

In the drawings accompanying that paper, the rocks under notice are referred to as "Lower New Red Sandstone," but in the text there is no statement indicating Prof. Sedgwick's opinion as to their age. He speaks of them as occurring at two or three places near Whitehaven, and a little north of Workington, and "as forming, apparently a connecting link between the true Carboniferous and New Red Sandstone groups." He further says that they "make a very near approach to a true coal-grit," and that by "the coal viewers of the neighbourhood they have always been regarded as a true member of the Coal-measures." In "The Coal-fields of Cumberland," etc., by Mr. Mathias Dunn,† these rocks along the coast are called "Lower Red Sandstone." They are said to occur at Crosby as well as near Whitehaven.

Mr. E. W. Binney in a paper "On the Permian Beds of the North-west of England,"‡ says, when referring to the Whitehaven Sandstone, as seen in the cliffs near the town, the purple sandstone is generally considered by Prof. Sedgwick and others, to be Lower New Red Sandstone,

* "On the New Red Sandstone Series of the Basin of the Eden and North-west Coasts of Cumberland and Lancashire." *Trans. Geol. Soc.*, second series, vol. iv., page 383.

† *Trans. N.E. Inst.*, vol. viii., page 141.

‡ *Mem. Lit. and Phil. Soc., Manchester*, second series, vol. xii., page 209.

overlying the Coal-measures of Whitehaven, but with all respect to so great an authority, the writer is inclined to believe that it is a Carboniferous sandstone.

Mr. Binney in 1863, in a paper entitled "Further Observations on the Carboniferous, Permian, and Triassic Strata of Cumberland and Dumfries,"* modified the opinion just quoted and said that—

> This rock, if not to be classed as Permian, must be taken as Upper and unconformable Coal-measures . . . The chief reason which has induced me to remove them from the Carboniferous strata is the conglomerate character of the lower part of the sandstone, which, as previously stated, is more like a Millstone Grit than an Upper Coal-measure rock. For the present it appears to me desirable to retain it as Prof. Sedgwick first designated it, by the name of Lower Red Sandstone, or my name of Lower Permian.

In 1879, in a paper by the writer on "The Hæmatite Deposits of West Cumberland,"† and in the discussion which took place on that paper, the nature of the Whitehaven Sandstone was pointed out shortly, also the extent of its uniformity to the lower part of the Coal-measures near Whitehaven and Cleator Moor.

In 1882, Mr. T. V. Holmes, at one time on the Geological Survey of Cumberland, wrote on "The Distinctive Colours of the Carboniferous and Permian or Triassic Rocks of North Cumberland," and stated that—

> The Whitehaven Sandstone takes the place occupied by the Red Rock of Rotherham in Yorkshire, and like the Red Rock, the Whitehaven Sandstone was till quite lately considered to be either Permian or Triassic instead of Carboniferous.

He also says that in the neighbourhood of Rosegill colliery (south-west of Bullgill railway-station) the Whitehaven Sandstone is shown in many quarries.

In 1883, the writer published a paper on "The Structure of the Cumberland Coal-field,"‡ which for the first time dealt with the Whitehaven Sandstone Series over the whole field, showing it to be unconformable Upper Coal-measures. To some of the conclusions arrived at in that paper with regard to the Whitehaven Sandstone Series, Mr. Holmes objected in "Notes on the best Locality for Coal beneath the Permian Rocks of North-west Cumberland."§ He denied that the purple-grey rocks lying to the north-east of Aspatria were unconformable to those below and looked upon them simply as stained Middle Coal-measures. In a short communication,‖ bearing the same title, the writer replied to the criticisms

* *Mem. Lit. and Phil. Soc., Manchester*, third series, vol. ii., page 343.

† *Trans. N.E. Inst.*, vol. xxviii., page 109.

‡ *Ibid.*, vol. xxxii., page 319, and vol. xxxiii., page 121.

§ *Trans. Cumberland and Westmorland Assoc.*, 1883-84, No. 9.

‖ *Ibid.*, 1883-4, No. 11, page 109.

of Mr. Holmes pointing out as a most extraordinary fact, if Mr. Holmes' view were correct, that none of the coal-seams in the Middle Coal-measures had been found in these purple-grey rocks, either in the particular area now referred to or elsewhere throughout the field.

In 1891, Mr. Wm. Brockbank noticed shortly the Whitehaven Sandstone in a paper on "The Occurrence of the Permians, *Spirorbis* Limestones, and Upper Coal-measures at Frizington Hall in the Whitehaven District."* Mr. Brockbank thinks that certain beds of Whitehaven Sandstone met with in a borehole near Frizington Hall belong to the Middle Coal-measures, "as they are 214 feet under the lowest *Spirorbis* Limestone." But surely mere thickness of strata cannot, of itself, determine geological level.

Within the last three years, the Geological Survey maps of the district have been published. On the Whitehaven sheet, the Whitehaven Sandstone Series is shown by a distinct colour. On the Maryport sheet, and at the western side of the Aspatria sheet, it is simply indicated by the letters W.S., whilst throughout the north-eastern part of the coal-field its existence is entirely ignored.

There appears to have been a conflict of opinion among the surveyors responsible for these maps, and that is mainly why the following notes have been put together, so as to give the members an opportunity of discussing the subject.

It was thought, with the rare opportunities possessed by the officers of the Geological Survey in the way of obtaining information and the vast amount of time (21 years) spent by them on the coal-field, that they would have satisfactorily settled the question. But they have done practically nothing towards it, which is much to be regretted, as the omission greatly reduces the value of the maps.

The geological position of the rocks in question is shown below :—

Permian or Triassic (?)—
- St. Bees Sandstone.
- Red shales with gypsum.

Permian—
- Magnesian Limestone.
- Breccia.

Carboniferous—
- Whitehaven Sandstone Series or Upper Coal-measures.
- Middle Coal-measures.
- Lower Coal-measures.

The Whitehaven Sandstone Series yielding few organic remains, and none, so far as is known, of undoubted value in fixing its precise geological

* *Mem. Lit. and Phil. Soc., Manchester*, fourth series, vol. iv., page 418.

horizon, the questions to be presently discussed will have to be treated without this great aid to stratigraphy.

The area of the rocks under consideration, according to the writer's field notes, as shown in Fig. 1 (Plate V.), will be seen to differ considerably from the maps published by the Geological Survey Fig. 2 (Plate V.), the latter not recognizing the Whitehaven Sandstone Series lying to the north-east of Beech Hill, near Oughterside, and also near Dearham.

The character of the rocks forming the Whitehaven Sandstone Series in different parts of the field will be seen from the sections (Appendix A) taken in areas where that series of rocks is admitted to occur by all observers with whom the writer is acquainted except one, who maintains that there is no evidence to show that the Whitehaven Sandstone in any part of the field is anything more than a stained Middle or Lower Coal-measure rock which may occur on different horizons in different parts of the field.

It will be seen from these sections (Appendix A) that the Whitehaven Sandstone Series consists almost entirely of sandstone and shale, of a red, grey, or brown colour, as described in the sections, but the writer prefers to call it purple-grey. With these beds are intercalated, in the lower part of the series, rocks of the ordinary Coal-measure colour and a few thin coal-seams. Two thin beds of *Spirorbis* limestone have been met with in the series at Frizington Hall, and occasionally, in different parts of the district, inconstant beds of conglomerate appear, as in section No. 3. In the neighbourhood of Flimby and Maryport, the base of the series is formed by a thick sandstone, as seen in section No. 6. At Whitehaven, Cleator Moor, and Frizington, the base-rock is variable, being in some places argillaceous, in others arenaceous. This variability of the base-rock is regarded by Mr. A. Strahan* as strongly suggestive that these reddish rocks are simply parts of the Middle and Lower Coal-measures that have undergone Permian or post-Permian staining. But surely such a view ignores altogether the character of the rocks. The series is much more arenaceous, and contains very much less coal, than the Middle Coal-measures, as will readily be seen on comparing the following sections (Appendix B) of Middle Coal-measures with those of the Whitehaven Sandstone Series just given. This will also be seen at a glance on reference to Fig. 3 (Plate VI.).

There is no bed in the coal-field that can be said to extend over the entire area, the argillaceous and arenaceous rocks (of which it almost

* Of the Geological Survey.

exclusively consists) often changing horizontally in the most erratic manner. And there is no reason why the lowest bed of a series should be more persistent and uniform in character than any of those which follow. Had there been a change from sedimentary to organic conditions, and had the lowest bed of the Whitehaven Sandstone Series been a limestone, there would have been a well-defined base, but seeing that all the rocks in both the Lower and Middle Coal-measures, as well as in the Whitehaven Sandstone Series, are of the same lithological character, it is not surprising that the base should be variable and difficult to detect.

From a number of sections taken at random in different parts of the district, the different sections ranging from 131 to 450 feet in depth, and embracing an aggregate thickness of more than 2,000 feet of rock, it appears that the proportion of arenaceous and argillaceous rocks in the Whitehaven Sandstone Series, and in a like thickness of Middle Coal-measures occurring immediately below the purple-grey rocks of the former series, is, on the average, as under:—

	Sandstone. Per Cent.	Shale. Per Cent.
Whitehaven Sandstone Series	60 ...	40
Middle Coal-measures	34 ...	66

The aggregate thickness of coal in the above sections was as follows:—

	Feet.	Per Cent.
Whitehaven Sandstone Series	7½	or 0·3
Middle Coal-measures	122	or 6·0

It is thus seen that there are at least two striking differences in the nature of these two series of rocks, differences that could not possibly have arisen if the Whitehaven Sandstone Series had been simply stained Middle Coal-measures; and similar differences can be shown to exist between the former rocks and the Lower Coal-measures. If the Whitehaven Sandstone Series be merely stained Middle Coal-measures, why do we not meet with the principal seams of the Middle Coal-measures in the purple-grey rocks which form so large a part of the Whitehaven Sandstone Series? for, as will hereafter be seen, these rocks in some cases are close down upon the base of the Middle Coal-measures.

The suggestion of staining may also be considered in the light of another set of facts. No matter whether we assume the Whitehaven Sandstone to be merely a stained rock, occurring on different horizons in the Middle and Lower Coal-measures, or whether we look upon it as part of a series of rocks which overlie the prolific part of the coal-field, and which have been subjected to a process of staining, we might naturally expect, other things being equal, that where these purple-grey rocks are overlain by the Permian beds the staining would extend,

roughly, to the same depth. Now, what do we find? At Demesne Gill, the thickness of these purple-grey rocks under the Permian rocks is only about 20 feet. At Croft pit, only one mile from Demesne Gill, it is about 175 feet. Inland, towards the north-east, we find much greater thicknesses, as shown below:—

	Thickness of Whitehaven Sandstone Series where Covered by Permian. Feet.
Cleator Moor, Henry pit	194½
Frizington Hall	531¼*
Bigcroft	327
Arlecdon	356½*

* Base not reached.

These figures suggest that the purple-grey colour is not due to Permian staining, but that it existed before the Permian rocks were deposited, and this seems to be proved conclusively by the arrangement of rocks near Preston Hows, as shown in Figs. 4 and 5 (Plate V.) The Whitehaven Sandstone Series there is intersected by a fault *EF* which has an upthrow to the south-east of about 150 feet. This fault is pre-Permian, undoubtedly; although it is shown on the Geological Survey map to have had a movement since the Permian beds were deposited. There is, however, no evidence of any such movement, but if there were it would not affect the present argument, for the movement must have been very small compared with that which took place at an earlier period, and which shifted the Whitehaven Sandstone Series nearly ¼ mile, before the Permian beds came into existence. The comparatively great difference in the thickness of the purple-grey rocks on opposite sides of the fault proves, it is submitted, in the most complete manner, that these rocks were not stained in Permian times, nor after. They have been faulted since they were coloured. The faulting is pre-Permian and consequently the colouring is pre-Permian.

Most probably they had their present colour when laid down. Why should not the conditions which ultimately gave rise to the deep red colour of the Permian beds have been introduced gradually, and at first somewhat interruptedly, so as to produce the alternation of purple-grey with the ordinary Coal-measure colour which is found near the base of the Whitehaven Sandstone Series? If the purple-grey colour were due to Permian staining, why have the beds in association with coal-seams not been affected? Sections Nos. 3 and 6 show that these beds have the ordinary Coal-measure colour, and this is invariably the case.

Let us now look at the series from another point of view, and take the thickness of strata between any well known coal-seam—as for example the Yard band—and the base of the Whitehaven Sandstone Series. In this examination great variations are found, as shown on the next page.

	Thickness of Strata between the Yard Band Coal-seam and the Base of the Whitehaven Sandstone Series. Feet.
Workington, St. Helens Colliery	599
Flimby, New pit	533
Maryport, Ellenborough pit	544
Whitehaven, Croft pit	489
„ Moss pit	280
„ Low Wreah...	186
Cleator Moor, No. 1 pit, Whinny Hill	451
„ Lindow pit	357
„ No. 2 pit, Threapthwaite	236
Frizington Colliery	305
Bullgill, Rosegill pit	410
„ Crosby pit	388
„ Ellen pit...	375

Over the area embraced by the places named in the preceding table, there is no material thickening or thinning of the Middle Coal-measures, so that the above variations may be taken to show approximately the amount of unconformity between the Whitehaven Sandstone Series and the Middle Coal-measures. In fixing the base of the Whitehaven Sandstone Series, it is necessary to take into consideration all the features of that series, viz., the colour, the excess of sandstone, and the extreme poverty in coal.

The unconformity thus presented will be still more evident when it is stated that the base of the Whitehaven Sandstone Series at Fairfield is only 75 feet above the china band coal-seam, which occurs at the base of the Middle Coal-measures, and about 200 feet below the yard band coal-seam from which the measurements in the preceding table were taken. At Studfield, there is 135 feet, and at Dean Moor 130 feet between the china band coal-seam and the base of the Whitehaven Sandstone Series. It may also be pointed out that, owing to the south-westerly attenuation of the Whitehaven Sandstone Series, the angle of unconformity between the Permians and the Middle Coal-measures is less than that between the latter rocks and the Whitehaven Sandstone Series. A similar south-westerly attenuation of the Permian breccia makes the angle of unconformability of the St. Bees Sandstone still less as shown in Fig. 6 (Plate VI.).

So long as the possibility of Permian staining was admitted there was considerable difficulty in the way of proving the unconformity satisfactorily, because the Permian beds are admittedly unconformable to the Coal-measures, and therefore if the purple-grey rocks of the Whitehaven Sandstone Series had been coloured by subsequent staining, there

would be an apparent unconformity between the stained rocks and those below that were unstained, and in the absence of a well-defined base-rock to the Whitehaven Sandstone Series, it might be open to question whether the lower limit of the supposed staining cut across the strata or was parallel to it. This difficulty arises mainly from the fact already alluded to that the purple-grey rocks are mostly arenaceous and argillaceous, like those of the Middle and Lower Coal-measures, and none of the beds in them are very persistent any more than such beds are in the Coal-measures generally, so that the base of the purple-grey rocks may at one place be formed by a sandstone, whilst at another, not far distant, it may be shale. Then, again, the purple-grey colour alternates with the ordinary Coal-measure colour near the base of the Whitehaven Sandstone Series, so that it becomes very difficult indeed to fix the lower limit of the series exactly. The figures given above, relating to unconformity, of course are entirely dependent upon the accuracy, or otherwise, of the correlations of the coal-seams in the Middle Coal-measures, and here it may be mentioned that there are several most important differences in the correlations arrived at by Mr. R. Russell,* and set out on the published vertical sections of the Geological Survey, and those at which the writer arrived in 1883, and which he still maintains to be correct.

Mr. Russell's correlations, speaking generally, lead to a great increase in the number of coal-seams in the coal-field; they do not, however, affect any of the above measurements from the yard band coal-seam, but those made from the six-quarters coal-seam, or rather its equivalent, they do affect, for Mr. Russell, in the area embracing Oatlands, Studfold, Dean Moor, and Moor Side, looks upon the china band (which the writer considers to be correlative of the six-quarters coal-seam of Whitehaven) as the equivalent of the five-feet coal-seam of Cleator Moor, a seam which is about 400 feet higher in the measures than the six-quarters coal-seam. If Mr. Russell were right all the principal coal-seams in the field should be below the china band, in the district named, but they are not, for that fact has been conclusively ascertained by boring, the underlying rocks having the character of the Lower Coal-measures.

The difference between Mr. Russell and the writer in this particular part of the coal-field appears to have arisen in this way. In certain parts of the coal-field, towards the top of the Middle Coal-measures, there are three seams, the equivalents of the five feet, four feet, and six feet coal-

* Formerly on the Geological Survey.

seams of Cleator Moor, which, when seen in vertical section, with the associated rocks, have a very close resemblance to three other seams at t bottom of the Middle Coal-measures, the lowest of the latter three bei the six-quarters coal-seam. If these two groups of coal-seams were co sidered without reference to their underlying strata it would, in ma cases, be impossible to distinguish between them, but when viewed relation to the subjacent rocks, their identity is easily determined. Fig. (Plate V.) exhibits several sections, within the area above alluded t showing the Whitehaven Sandstone Series close down upon the chi band coal-seam. It also gives a section of the strata at Gilgarr immediately adjacent. Now the coal-seams there are identified common consent, the yard band being considered the same as the s quarters coal-seam of Whitehaven. By comparing these sections it evident that the china band at Studfold and Oatlands, and the low se at Dean Moor, are parts of the same seam as the yard band at Gilgarr This conclusion is supported by the workings of the Moresby collier and others in the immediate neighbourhood, as shown by the longitudi section Fig. 8 (Plate VI.), the throw of the different faults therein havi been ascertained by the actual workings of the mines.

The base of the Whitehaven Sandstone Series is therefore, as alrea stated, only 75 feet above the china band or six-quarters coal-seam at Fa field, whilst at the Croft pit, near Whitehaven, and 4 miles distant fr Fairfield, it is about 700 feet above that coal-seam, the difference showi partly the amount of unconformity, there being numerous faults betwe Fairfield and Croft pit, older than the Whitehaven Sandstone Series, wh have an aggregate net upthrow, towards the latter place, of about 1,0 feet, and these have the effect of making the apparent much less than t real unconformity. The unconformity is further illustrated by Fig (Plate VI.).

It being now clear, it is submitted, that the Whitehaven Sandst Series, south of Oughterside, is an unconformable part of the Coal-measu let us investigate the area to the north-east of that place, and in the fi place, it may be well to point out that all the principal faults intersecti the coal-field between Oughterside and Bolton Low Houses, are down the north-east, making it highly probable that the purple-grey ro found near Oughterside, and which are admitted by Mr. Holmes and M Russell to belong to the Whitehaven Sandstone Series, will be repeat throughout the area to the north-east.

Now, what is found? Exactly what might have been expected, t the purple-grey rocks are there. Appendix C contains a number

sections obtained by sinking and boring through these rocks, the tints of which, as before, are described as red, grey, or brown, and will hereinafter be referred to as purple-grey.

In these sections (Appendix C) as in Nos. 1 to 8 inclusive (Appendix A), it is found that the proportion of sandstone to shale is greater than in the Middle Coal-measures, where the purple-grey colour is absent. The sections also show very little coal as compared with those of the Middle Coal-measures.

The difference between section No. 16 and Nos. 9 to 13 inclusive, and its general correspondence with Nos. 1 to 8 inclusive, will be seen at once on reference to Fig. 3 (Plate VI.). Nos. 14 and 15 are omitted from this view, because they are so shallow, and include an unusual proportion of coal in comparison with their depth.

The Whitehaven Sandstone has so peculiar an appearance that the writer would have thought it sufficient merely to assert the identity of the rocks at Rosegill, Watch Hill, near Baggrow, Allhallows colliery, Priestcroft, and near Bolton New Houses, were it not that Mr. T. V. Holmes has thought otherwise. So far as we know, it was simply lithological likeness which enabled Prof. Sedgwick and all later observers to affirm the identity of the purple-grey rocks at Whitehaven and elsewhere along the coast.

Even Mr. Holmes, for no other reason that is given, considers that the purple-grey rock at Rosegill is the same as that seen near Whitehaven, notwithstanding that the two places are 13 miles apart, and although, in about 9 miles of the intervening ground, there is not a trace of the rock to be seen. Surely if the characters of this rock are sufficiently marked to enable anyone to recognize it in isolated areas so far apart as Whitehaven and Rosegill, there should be no difficulty between the latter place and Bolton New Houses, for the rock is practically continuous between these two places, and therefore any change of lithological character might be easily traced. For the purpose of following the purple-grey rocks, step by step, from the area in which they are admitted to be Upper unconformable Coal-measures, to that in which they are not so admitted, by the geological surveyors, Fig. 9 (Plate VI.) has been prepared.

The rocks in these sections, above the line drawn as the base of the Whitehaven Sandstone Series, are, to a large extent, of a purple-grey colour, but with them, especially where coal-seams occur, are beds of the ordinary Coal-measure tints. The total thickness of strata shown in these sections as being in the Whitehaven Sandstone Series, is 2,833 feet, 37½ per cent. of which is sandstone and 62½ per cent. is shale. The aggregate thickness

of coal is 51 feet, or about $1\frac{3}{4}$ per cent. of the whole. The average thickness of the seams is about $10\frac{1}{2}$ inches.

The strata in the Middle Coal-measures, as represented in these sections, have a gross thickness of 1,345 feet, the sandstone occupying 25 per cent. and the shale 75 per cent. of the whole. The coal is 101 feet or nearly 8 per cent. of the total thickness of strata, and the average thickness of the seams is about 30 inches.

In comparing these sections (Nos. 1 to 8 inclusive) with those in Fig. 3 (Plate VI.) taken in the southern part of the coal-field, two differences present themselves, (*a*) the larger proportion of shale, and (*b*) the greater thickness of coal which appears in these sections at the north-eastern end of the field. Still, here, as there, the Whitehaven Sandstone Series is more arenaceous and contains very much less coal than the Middle Coal-measures.

Let us now see if these rocks are unconformable to the Middle Coal-measures, because Mr. Holmes denies that they are. Taking the Ellenborough section, we have, below the Senhouse high band coal-seam, a bed of purple-grey sandstone *S*, the bottom of which is 560 feet above the yard band coal-seam, and this sandstone, in sheet 75 of the vertical sections of H.M. Geological Survey of Cumberland, is described as Whitehaven Sandstone. With that the writer agrees, but he goes further than Mr. Russell does, and says that the whole of the rocks above this bed up to the surface belong to the Whitehaven Sandstone Series.

Now pass on to Crosby. The principal seams there and at Ellenborough are easy of identification from the yard band up to the ten-quarters coal-seam ; but above that there is a difficulty, and we find no correspondence whatever in the two sections until we reach the Whitehaven Sandstone *S* in the Ellenborough section, the seams between that rock and the ten-quarters coal-seam at Ellenborough being absent from the Crosby section.

On the surface, at and near Crosby, is a purple-grey sandstone which Mr. Holmes admits to be Whitehaven Sandstone. In the journal of the shaft-sinking, rocks of the same colour *T* are recorded to a depth of 225 feet. Then follow rocks of the ordinary Coal-measure hues, and over the ten-quarters coal-seam is a white sandstone. This, notwithstanding the absence of colour, the writer looks upon as the equivalent of the bed *S* at Ellenborough.

On reaching the next section, near the bridge over the river Ellen, we find confirmation of this supposition, for the sandstone beds *U* have the purple-grey colour. We also find it in the next section at *V* in some

of the layers of rocks. At Allhallows, the colour of the bed, when given in the journal, is said to be grey, but at Bolton No. 2 pit, and No. 5 borehole, the sandstone beds *W* have all the purple-grey tint.

Taking the bed which we have just traced through the sections as the base of the Whitehaven Sandstone Series we see at a glance how great is the unconformity. The yard band in these different sections is generally admitted to be the same seam. In the Crosby section we can trace all the other coal-seams of the Middle Coal-measures that are found at Ellenborough, up to and including the ten-quarters coal-seam. Then these measures stop. Near the bridge over the Ellen river, and at Aspatria, No. 3 pit, the rattler coal-seam and the ten-quarters coal-seam have disappeared. At Allhallows, the 30 inches coal-seam of Bullgill has gone, and that name has been given to a coal-seam which is the equivalent of the metal band of Bullgill. At No. 2 pit, Bolton, there is not a single coal-seam left in the Middle Coal-measures above the yard band.

The difficulties facing anyone attempting to correlate the seams of the Middle Coal-measures above the ten-quarters coal-seam at Ellenborough, with the seams in any of the other sections are, it is submitted, insurmountable, and the same statement may be extended to all the coal-seams above the yard band lying to the north-east of Allhallows.

Now let us see what is obtained by viewing the rocks in the way just suggested. Commencing at the Ellenborough section, we have, in these purple-grey rocks, several seams of coal, but there are two of more importance, practically, than any of the others. One is known as the Senhouse high band, and is about 44 inches thick. The other occurs about 30 feet below that seam, and is about 2 feet thick. In the Crosby section we have what may be fairly taken to represent these two coal-seams, allowance being made for the intervening distance. Near the bridge over the Ellen river only the lower seam is seen, but thence we find the two seams in each of the other sections, and still further to the north-east at Bolton old colliery, they have been extensively worked under the names of the crow band and master band, the latter being the lower of the two. The depth of this seam at the Lady pit is 302 feet.

As regards the smaller coal-seams higher in the sections it is useless to attempt any correlation, they are so inconstant, as in fact such coal-seams usually are.

Having now, it is submitted, proved what was the writer's intention to prove, and what in fact he had already shown in 1883, he would, in

conclusion, merely point out that Mr. Holmes by assuming these purple-grey rocks to be stained Middle Coal-measures has been led into other errors, for on the Aspatria sheet partly prepared by him, in the area lying immediately to the north-east of the coal-field, he has coloured as belonging to the Millstone Grit and Carboniferous Limestone Series rocks which also belong to the Whitehaven Sandstone Series or Upper Coal-measures.

If lithological character goes for anything, and it is trusted over wide areas by very competent observers, then the purple-grey rock seen at Nine Gills and elsewhere adjacent in Shalk beck is Whitehaven Sandstone. This is only what might be expected. The east-and-west fault which passes near Parson Bridge is down to the north, and therefore in the lenticular area lying to the north-east of the coal-field, and which is shown as Millstone Grit on the geological map, we should expect the purple-grey rocks of Bolton New Houses to be repeated, just as they are repeated by similar faults north-east of Oughterside. There are other Carboniferous rocks besides those mentioned, more to the east, that have a purplish hue, but they are very different from the Whitehaven Sandstone, in tint, composition, and structure, and could never be mistaken for Whitehaven Sandstone, even in hand specimens, by anyone familiar with that rock.

Against the positive evidence afforded by exact lithological correspondence, Mr. Holmes opposes the negative argument that because the purple-grey rocks along the Shalk beck are lying at a high angle it is difficult to conceive any Carboniferous rocks lying at a higher angle below, which, of course, there ought to be, if the purple-grey rocks that he has placed in the Millstone Grit and Carboniferous Limestone Series belonged to the unconformable Whitehaven Sandstone Series. Now, when it is known that the angle of unconformity between the Middle Coal-measures and the Whitehaven Sandstone Series is less than 5 degs. Mr. Holmes' objection disappears entirely, for however high the angle of dip might be, it is very easy to understand how that of underlying rocks could be steeper by only 5 degs.

To conclude, the facts on which the writer chiefly relies in separating the Whitehaven Sandstone Series from the Middle and Lower Coal-measures and classing it as Upper Coal-measures are :—

(*a*) That it contains very little coal, and that mainly near its base.

(*b*) That it is very much more arenaceous than either the Middle or Lower Coal-measures.

(*c*) That it always occurs above the well-known coal-seams of the Middle and Lower measures.

(*d*) That it is unconformable to the Middle and Lower measures.

(*e*) The purple-grey colour being pre-Permian as demonstrated by the faulting near the Croft pit, Permian or post-Permian staining is out of the question.

(*f*) The absence of the purple-grey colour from the rocks of the Middle and Lower Coal-measures whenever the determination is beyond doubt.

Appendix A.—Sections of the Whitehaven Sandstone Series.

1.—*Croft Pit, near Whitehaven.*

Description of Strata.	Thickness of Strata. Ft.	In.	No.	Description of Strata.	Thickness of Strata. Ft.	In.
Reddish soft sandstone ...	1	6	8	Blue shale, with spots of COAL	0	9
Red shale, with layers of sandstone	2	6	9	Red shale	13	0
Red sandstone	42	6	10	Black shale	1	0
Soft red shale	0	6	11	Ash-coloured shale	4	0
Red shale, with thin layers of sandstone	52	0	12	Purple shale, with layers of sandstone	27	3
Strong red sandstone (greyish)	29	9				
Lumpy red sandstone ...	0	9		Total	175	6

2.—*Henry Pit, Cleator Moor.*

Red sandstone	6	0	9	Red sandstone	38	0
Red shale	3	0	10	Reddish shale	1	0
Grey sandstone	3	0	11	Red and white sandstone ...	67	6
Clay	0	6	12	Reddish shale	18	0
Grey sandstone	18	0	13	Hard grey sandstone ...	27	0
Red sandstone	2	0				
Sandy shale	0	6		Total	194	6
Grey sandstone	10	0				

3.—*Bore-hole at Frizington Hall.*

Red shale	9	4	13	Grey sandstone	31	11
Mottled shale	7	0	14	Red shale	5	9
Soft purple micaceous sandstone	9	2	15	Undescribed	11	6
Purple and green shale ...	4	0	16	White limestone *	1	0
Red shale	39	7	17	Red sandy shale	2	6
Reddish limestone * ...	3	9	18	Mottled shale	16	0
Purple sandy shale	10	8	19	Dark purple brecciated marl	5	0
Conglomerate	11	0	20	Grey sandstone	1	6
Grey and pink shaly sandstone	6	0	21	Red and grey shale	1	10
Shaly conglomerate	39	1	22	Blue shale	7	0
Red shale	6	0	23	COAL, pyritous	0	4
Red and grey micaceous sandstone	5	6	24	Blue shale, striated red, plant remains	2	9

* Mr. W. Brockbank has found species of *Spirorbis* and *Ostracoda* in these beds; and in a valley not far distant from this hole, the writer, in company with Mr. Strahan of the Geological Survey, has seen *Spirorbis* in detached pieces of limestone.

No.	Description of Strata.	Thickness of Strata. Ft.	In.
25	Grey sandstone	1	0
26	Blue shale, striated red, plant remains	10	10
27	Fireclay	3	10
28	**COAL**	1	0
29	Blue shale	11	0
30	Grey fireclay	5	0
31	Red shale, with thin bands of blue shale	5	8
32	Greenish marl	15	4
33	Fireclay	7	11
34	Blue shale	33	2
35	Fireclay	2	0
36	Blue shale	8	10
37	**COAL**	1	3
38	Blue shale	10	8
39	Red shale	1	0
40	Red sandstone	6	11
41	Red shale	5	0
42	Reddish-grey shale	7	2
43	Reddish-grey sandstone ...	6	4
44	Red sandy shale	6	0
45	Reddish sandstone	10	4
46	Sandstone, with beds of soft purple shale	17	2
47	Mottled sandy shale ...	15	2
48	Red shale, with beds of sandstone	10	3
49	Mottled shale	5	8
50	Purplish sandstone	21	7
51	Conglomerate	11	10
52	Reddish-grey sandstone ...	11	6
53	Dark purple shale	7	0
54	Reddish-grey sandstone ...	12	5
	Total, but base was not reached	511	0

4.—*Bore-hole at Bigcroft.*

1	Permian breccia	?	
2	Red sandstone	35	3
3	Shaly sandstone	19	0
4	Hard sandstone	3	6
5	Shaly sandstone	9	9
6	Red shale	6	0
7	Hard sandstone	3	0
8	Shaly sandstone	5	6
9	Red sandstone	40	6
10	Shaly sandstone	3	0
11	Hard sandstone	5	6
12	Shaly sandstone	3	6
13	Soft shale	2	0
14	Red sandstone	2	6
15	Red shale	2	0
16	Shaly sandstone	2	0
17	Hard sandstone	23	6
18	Softer sandstone	2	0
19	Hard sandstone	35	0
20	Red sandstone	41	6
21	Sandy fireclay	2	6
22	Red sandstone	10	6
23	Red shaly sandstone ...	15	0
24	Shaly sandstone	16	0
25	Red shale	17	6
26	Grey sandy shale	20	6
	Total	327	0

5.—*Bore-hole near Arlecdon.*

1	Permian breccia	?	
2	Red shale	70	9
3	Grey sandstone	3	9
4	Red shale	3	6
5	Red sandstone	5	0
6	Red shale, with grey bands	48	0
7	Grey shale	2	8
8	Red shale	14	4
9	Grey sandstone, with red bands	5	9
10	Red shale, with grey bands	11	8
11	Red shale	17	7
12	Grey shale	2	9
13	Red sandstone	7	5
14	Red shale	41	10
15	Red sandstone	19	0
16	Grey sandstone, randed red, and much lime	24	3
17	Soft red sandstone, with hæmatite	10	0
18	Red sandstone, with lime ...	40	8
19	Soft red shale	14	7
20	Hæmatite	0	5
21	Grey shale, with lime ...	2	6
22	Black shale	2	2
23	Red shale and grey bands ...	2	9
24	Hæmatite	0	6
25	Red shale, randed grey ...	0	8
26	Grey shale	2	0
27	Grey shale, with bands of **COAL**	0	5
28	Grey shale, randed red ...	1	5
	Total, but base was not reached	356	4

6.—*New Pit, Flimby.*

ription of Strata.	Thick-ness of Strata. Ft.	In.
sandstone	12	7
, *senhouse high band*	2	8
rey fireclay	8	0
ne	0	6
rey shale	15	6
lue shale	11	9½
, slaty	2	0½
ey fireclay	1	3
idstone	0	10
ale	4	9
idstone	103	0
iale	8	6

No.	Description of Strata.	Thick-ness of Strata. Ft.	In.
13	White sandstone	6	4
14	Black shale	4	2
15	**COAL**	2	4
16	Dark grey fireclay	4	6
17	Grey sandstone	1	10
18	Grey shale	2	3
19	**COAL**	0	11
20	Grey fireclay	3	3
21	Grey shale	13	6
22	Red sandstone	30	9
	Total	241	3

7.—*Bore-hole near Risehow House, Flimby.*

sandstone	18	4	7 Red and white shale ...	24	6
idstone	14	0	8 Brown sandstone	6	0
sandstone	22	8	9 Red shale	12	0
ale	2	0	10 Red sandstone	23	0
d blue shale	4	0			
idstone	4	6	Total, but base was not reached	131	0

8.—*Rosegill Pit, near Bullgill.*

ale	6	0	36 Black shale	1	0
grey sandstone ...	91	6	37 White fireclay	2	0
ale	14	0	38 White sandstone	4	0
ppled fireclay ...	5	6	39 Dark shale	5	0
... ...	10	0	40 **COAL**	0	3
grey sandstone ...	6	0	41 Fireclay	4	0
ppled fireclay ...	5	0	42 Light shale, with ironstone	15	6
... ...	9	4	43 Dark shale	21	6
andstone, mixed with			44 **COAL**	0	3
... ...	2	6	45 Dark shale	0	3
ale	0	8	46 **COAL**	0	1
... ...	6	0	47 Dark shale	6	6
iale	2	3	48 **COAL**	1	9
oloured shale ...	3	0	49 Dark fireclay, with beds of		
ed shale	9	0	sandstone	5	10
andstone	1	6	50 Grey sandstone	17	6
ale	7	0	51 Dark shale	5	6
oloured shale ...	1	0	52 **COAL**	1	2½
ale	11	0	53 Dark shale	1	2
andstone	28	6	54 **COAL**	0	2¾
ale	1	6	55 Dark fireclay, with sand-		
grey sandstone ...	3	0	stone	6	0
iale	8	6	56 Black shale	0	10
one	0	4	57 Shale	0	8½
lue shale	7	6	58 **COAL**	0	3½
hale	0	2	59 Dark fireclay	3	10
luish sandstone ...	1	0	60 White sandstone	6	0
shale	0	2	61 Shale	5	6
. ...	0	2	62 Fireclay	5	0
ay	4	3	63 **COAL**	0	11
sandstone	7	6	64 Shale	0	7
sandstone	9	0	65 **COAL**	0	1
ed red sandstone ...	4	6	66 Grey fireclay	4	0
ireclay	1	6	67 Shale, with beds of freestone	51	0
ed red sandstone ...	2	0			
hale	12	6	Total	461	7¼

APPENDIX B.—SECTIONS OF MIDDLE COAL-MEASURES.

9.—Croft Pit, near Whitehaven, from the base of the Whitehaven Sandstone Series.

No.	Description of Strata.	Thickness of Strata Ft.	In.
1	**COAL**	1	0
2	Whitish sandstone ...	10	2
3	Dark shale	4	11
4	**COAL**	1	10
5	Dark shale, mixed with **COAL**	2	6
6	Whitish sandstone	8	6
7	Bluish shale, mixed with grey sandstone	3	0
8	White ironstone	1	0
9	Sandstone, striated with blue shale	1	8
10	Sandstone, in thin beds ...	9	3
11	Dark-blue shale	13	6
12	**COAL**	0	9
13	Dark-grey shale	15	8
14	**COAL**, with 1 inch of shale	2	0
15	Grey sandstone, with ironstone	8	0
16	Hard white sandstone ...	15	6
17	**COAL**	1	0
18	Shale, mixed with sandstone	8	0
19	Olive-coloured shale ...	2	4
20	**COAL**	1	1
21	Black shale, mixed with sandstone	8	8
22	White sandstone, mixed with shale	8	0
23	Dark blue shale	22	4
24	**COAL**	1	3
25	Black shale, mixed with sandstone	7	6
26	Strong white sandstone ...	6	0
27	Ironstone	3	0
28	Dark-grey shale, with **COAL** about 5 inches thick ..	11	6
29	Light-coloured shale, mixed with sandstone	5	6
30	Blue shale, striated with sandstone	10	0
31	White sandstone	2	6
32	Black shale	10	3
33	**COAL**	0	4
34	Soft grey shale	0	3
35	**COAL**	0	8
36	Hard black shale	1	7
37	**COAL**, mixed with pyrites	1	2
38	Grey shale	3	0
39	Blue shale	7	6
40	Sandstone, mixed with ironstone	3	0
41	Dark blue shale	12	0
42	**COAL**	2	6
43	Shale, mixed with sandstone		
44	White sandstone		
45	Blue shale, with beds of white sandstone		
46	Light-blue shale		
47	Blue shale, with ironstone		
48	Black shale		
49	**COAL**		
50	Brownish hard shale ...		
51	Blue shale		
52	**COAL**		
53	Lightish-grey shale ...		
54	Sandstone, with beds of blue shale		
55	Blue shale, with beds of white sandstone		
56	Blue shale		
57	**COAL**, *bannock band* ..		
58	Grey shale		
59	Black shale		
60	**COAL**		
61	Light-coloured shale ...		
62	Blue shale, with beds of white sandstone		
63	Ironstone		
64	Grey shale		
65	Strong white sandstone ...		
66	Sandstone, with beds of dark shale		
67	Greyish shale		
68	Sandstone, with thin beds of blue shale		
69	Blue shale		
70	**COAL**, *main band* ...		
71	Fireclay		
72	Shale		
73	**COAL**		
74	Hard fireclay		
75	Banded shale		
76	**COAL**, cannel		
77	Shale		
78	**COAL**, cannel		
79	Fireclay		
80	Sandstone		
81	Shale		
82	**COAL**		
83	Fireclay		
84	Shale		
85	**COAL** and fireclay ...		
86	Fireclay		
87	Shale		
88	**COAL**		
89	Soft shale		

* The section below the main band coal-seam is that of the Wellington pit, Whitehaven.

No.	Description of Strata.	Thickness of Strata. Ft.	In.
90	**COAL**, bad	0	11
91	Fireclay	2	2
92	Shale	10	2
93	**COAL**	0	6
94	Fireclay	5	1
95	Dark sandstone	11	0
96	Randed shale	15	10
97	White sandstone	4	6
98	**COAL** and fireclay ...	1	2
99	Fireclay	3	2
0	Dark sandstone	18	0
1	Shale	14	0
2	Rattler	0	6
3	**COAL**	2	0
	Fireclay	4	6
	Randed shale	16	8
	COAL, cannel	1	0
	COAL, bad	1	8
	COAL, cannel	0	11
109	Soft shale	0	7
110	**COAL**	1	4
111	Shale	0	4
112	Fireclay	3	5
113	Randed shale and "catscopes"	19	0
114	Ironstone	0	10
115	Randed shale	1	0
116	**COAL**	1	8
117	Fireclay	2	6
118	Black shale	3	6
119	Ironstone	0	7
120	Black shale	0	11
121	**COAL**	1	0
122	Dark shale	4	4
123	**COAL** (*six-quarters coal-seam*)	7	7
	Total	689	3

D.—*No. 1 Bore-hole, Whinnyhill Pit, Cleator Moor, from the base of the Whitehaven Sandstone Series.*

	ey fireclay	5	0
	ey randed sandstone ...	5	0
	AL	2	2
	k fireclay	4	6
	k randed fireclay and tone	5	2
	ck shale	26	7
	ck shale, with "catcopes"	0	5
	AL	1	5
	y fireclay	21	0
	ite sandstone	2	0
	k grey sandstone ...	7	0
	e shale and "catscopes"	6	0
	AL	1	4
	eclay	7	0
	ht-coloured shale ...	4	0
	AL	0	8
	eclay	0	6
	nded shale	33	0
	t *coal-seam*—		
	COAL, with parting ½ inch thick	3	0
	Black shale	1	8
	COAL	1	8
	reclay	3	0
	rk randed shale, with a little sandstone	24	0
	rk randed shale	3	0
	ale and "catscopes" ...	1	3
	feet *coal-seam*—		
	COAL	1	3
27	Shale	0	9
28	**COAL**	2	3
29	Fireclay	1	0
30	White sandstone	6	0
31	Dark shale	3	0
32	**COAL**	0	1½
33	Dark shale	26	0
34	Black shale	0	8
35	Strong red shale	15	10
	Five-feet coal-seam—		
36	**COAL**	6	0
37	**COAL** and shale	3	0
38	**COAL**	0	4
39	Fireclay	0	6
40	Shale, upper part randed ...	21	0
41	White sandstone	6	0
42	Shale	2	0
43	Rattler	0	6
	Bannock band coal-seam—		
44	**COAL**	3	0
45	Shale	1	4
46	**COAL**	4	0
47	Fireclay	6	0
48	Shale	1	0
49	**COAL**	1	0
50	Fireclay and shale	2	0
51	Shale, with white sandstone	8	0
52	Sandstone	84	0
53	Grey shale	5	0
54	**COAL**, *main band coal-seam*	9	0*
55	Fireclay	5	0
56	White sandstone	4	0

* The section below the main band coal-seam is that of the No. 2 pit, Cleator Moor.

No.	Description of Strata.	Thickness of Strata. Ft.	In.
57	Shale, with thin ironstone ...	17	6
58	**COAL**	0	6
59	Fireclay	1	6
60	Shale and two bands of ironstone	12	7
61	**COAL**, coarse cannel ...	1	10
62	Shale and three bands of ironstone	8	2½
63	**COAL**, *yard band coal-seam*	3	0
64	Fireclay	1	4
65	Shale	15	0
66	**COAL**	0	8
67	Soft shale	1	9
68	**COAL**, bad	1	0
69	Fireclay	2	3
70	Shale	10	2
71	**COAL**	0	6
72	Fireclay	5	1
73	Dark sandstone	11	0
74	Randed sandstone	15	10
75	White sandstone	4	6
76	**COAL**	1	4
77	Fireclay	3	2
78	Dark sandstone	18	0
79	Shale	14	0
80	Rattler		6
81	**COAL**...		4
82	Fireclay		6
83	Randed shale...	1	8
84	**COAL**, cannel		0
85	**COAL**, bad		8
86	**COAL**, cannel		11
87	Soft shale		7
88	**COAL**		6
89	Fireclay		6
90	Randed shale...	1	10
91	Shale		0
92	**COAL**		10
93	Fireclay		6
94	Black shale		6
95	**COAL**		0
96	Grey shale		6
97	Dark shale		0
98	**COAL**, *low bottom band or six-quarters coal-seam of the Whitehaven district* ...	3	0
	Total	625	11

11.—*Frizington Colliery, No. 1 Shaft, from the base of the Whitehaven Sandstone Series.*

1	Grey shale	3	7
2	Sandstone	1	9
3	Dark-blue shale, with limestone balls	14	8
4	Shale	1	1
5	**COAL**, sparry	0	4
6	Light-grey fireclay	2	11
7	Dark-blue shale	24	6
8	**COAL**	0	8
9	Grey shale	0	9
10	**COAL**, stony	0	6
11	Dark shale	0	9½
12	**COAL**, good	1	7½
13	Shale	3	4½
14	Sandstone	1	5
15	Sandstone, in thin layers ...	1	3
16	Dark-blue shale	12	10
17	Grey sandstone	10	8
18	Dark-blue shale	7	11
19	Fireclay	0	6
20	Dark shale	7	3
21	**COAL**	3	9
22	Fireclay	0	8½
23	**COAL**	0	2
24	Shale	0	2
25	**COAL**	0	3½
26	Shale	0	4
27	**COAL**	0	6
28	Grey shale*	9	0
29	White sandstone	27	0
30	Black shale	1	6
31	**COAL**	2	6
32	Fireclay and white shale ...	4	9
33	**COAL**	1	6
34	White sandstone	75	0
35	Randed sandstone	18	5
36	White sandstone	9	11
37	Fireclay	1	4
38	White sandstone	1	5
39	Light shale	0	9
40	White sandstone	10	3
41	Dark shale	0	2
42	**COAL**	1	10
43	Fireclay	1	10
44	Randed sandstone and shale	18	11
45	Light-coloured shale and fireclay	11	4
46	Black shale	1	2
47	Light shale	7	8
48	**COAL**	1	7
49	Fireclay	2	0
50	Randed sandstone	14	6
51	**COAL**	0	8
52	Light shale and randed sandstone	22	6
	Total	351	9½

* The section below this point is that of a bore-hole in the bottom of the No. 1 shaft, Frizington colliery.

lenborough Pit, Maryport, from the base of the Whitehaven Sandstone Series.

ription of Strata.	Thickness of Strata. Ft.	In.
ıale	2	4
ıle, with "catscopes"	7	8
ale	36	0
... ...	2	4
ındy shale	0	3
ıloured fireclay ...	1	2
ıale	0	1½
ıloured fireclay ...	3	9
ıloured sandstone ...	3	0
ıloured shale ...	4	0
ıloured sandstone ...	1	1
ıloured shale ...	1	1
... ...	0	6
ıclay	4	0
ıloured sandy shale, 'catscopes" ...	18	0
hale mixed with a **COAL**	0	6
ıloured sandy shale, 'catscopes" ...	10	0
ıloured grey sandy	1	0
ıloured sandstone ...	1	3
ıloured sandy shale	6	0
ıloured sandstone ...	30	0
Hamilton coal-seam	7	0
ındstone	18	10
... ...	0	8
ale	71	0
virgin coal-seam ...	2	6
stony	7	8
with beds of sand-	26	9
ey shale	7	9
white metal band ıam	4	8
ıle	4	3
ıdstone	1	0
... .	4	6
ndstone	5	4
ıe shale	5	11
ıdstone	2	4
ıloured sandstone ...	5	10
ue shale, with "cats- "	7	0
... ...	0	3
ı *coal-seam*—		
L	2	0
mixed with **COAL**	0	8
L	0	10
... ...	0	3½
L	1	10
... ...	0	1½
L	0	8
bad	0	5
good	0	4
L	1	3
eclay	4	6
ıale, with "catscopes"	10	1

No.	Description of Strata.	Thickness of Strata. Ft.	In.
52	Fine light sandstone ...	6	3
53	Coloured shale, with "cats- copes"	10	3
54	**COAL**, *rattler band coal-seam*	5	2
55	Fireclay	5	0
56	Shale, with "catscopes" ...	16	4
57	Grey sandstone ...	2	4
58	Black shale	2	0
59	Sandstone	43	0
60	Shale...	0	5
61	Dark sandstone	26	2
62	Black shale	0	2
	Crow band coal-seam—		
63	**COAL**	1	0
64	Shale and spar	0	6
65	**COAL**	0	10¼
66	Black shale	1	7
	Metal band coal-seam—		
67	**COAL**	1	6
68	Shale	0	9
69	**COAL** and rattler ...	0	4½
70	**COAL**	0	10½
71	Grey fireclay	2	6
72	Blue shale	4	2
73	Grey sandstone	3	8
74	Blue shale	6	9
75	Dark grey shale	2	10
76	**COAL**, *cannel band coal-seam*	5	7
77	Light-grey shale	4	6
78	Dark shale with sand- stone	4	6
79	Shale	3	2
80	Black sandstone	2	3
81	Strong grey sandstone ...	1	6
82	Blue shale and sandstone ...	7	9
83	Light-coloured sandstone ...	3	5
84	Strong grey sandstone ...	0	10
85	Light-coloured sandstone ...	2	2
86	Shale and sandstone ...	4	7
87	Light-blue shale	2	9
88	**COAL** and splint	1	0
89	Light-coloured shale ...	7	6
90	Strong grey sandstone ...	5	2
91	Light-coloured sandstone ...	1	2
92	Strong grey sandstone ...	1	0
93	Shale and sandstone ...	1	0
94	Blue shale	14	0
95	**COAL** and splint	2	3
96	Light-grey shale	2	6
97	Sandstone	7	2
98	Shale...	4	0
99	Light-blue shale	2	5
100	**COAL**	0	3
101	White sandstone	3	4
102	Light-grey sandstone ...	2	0
103	Grey shale	1	3
104	Light-grey sandstone ...	2	0

No.	Description of Strata.	Thickness of Strata. Ft.	In.
105	Light-grey shale	2	0
106	Shale	3	0
107	Grey shale with "catscopes"	0	6
108	Light-blue shale	3	2
109	Catscopes	0	4
110	Black splint or shale ...	0	6
111	Blue shale and "catscopes"	5	7
112	Dark-grey shale	5	0
113	Catscopes	0	3
114	Dark-coloured shale ...	1	2
115	Strong grey sandstone ..	4	2
116	Dark-coloured shale ...	0	3
117	Sandstone	3	6
118	Blue shale and "catscopes"	7	2
119	Grey sandstone	0	4
120	Light-blue shale	0	10
121	Dark-blue shale	3	6
122	Light-blue shale	1	8
123	Dark shale	0	6
124	**COAL**	0	11
125	Shale	0	4
126	Light-grey fireclay		
127	Light-grey sandstone ...		
128	Light-grey shale		
129	White sandstone		
130	Light-grey sandstone ..		
131	Blue shale		
132	White sandstone		
133	Grey sandstone		
134	**COAL**		
135	Black shale		
136	Strong grey fireclay ...		
137	Dark shale		
138	Strong grey sandstone ...		
139	Grey shale		
140	Strong grey shale		
141	Grey sandstone		
142	Light-coloured shale with sandstone		
143	Blue shale		
			6

13. – *Rosegill Pit, Bullgill, from the base of the Whitehaven Sandstone Seri*

1	Dark shale with ironstone beds	15	0
2	**COAL**, *ten-quarters seam*	6	8*
3	Dark shaly fireclay	9	0
4	Light-blue shale	23	6
5	**COAL**, *rattler band coal-seam*	2	10
6	Light shaly fireclay	3	8
7	**COAL** and shale, *slaty band coal-seam*	7	0
8	Brown sandstone	9	3
9	**COAL**	1	0
10	Light-coloured shaly fireclay	2	3
11	Flinty sandstone	5	6
12	Blue shale	37	0
13	Black shale	3	6
14	**COAL**, 30 *inches coal-seam*	3	0
15	Black shale, with ironstone beds	8	6
16	**COAL**, *metal band coal-seam*	5	6
17	Light-coloured sandstone beds	6	6
18	Light-coloured shale ...	4	0
19	**COAL**, *cannel seam* ...	11	0
20	Shaly fireclay	3	0
21	Strong blue shale	8	0
22	Black stone and rattler ...	2	0
23	Black shale	2	0
24	Light-blue shale and thin beds of sandstone	20	0
25	**COAL**, with rattler on the top	1	0
26	Light-blue shale	21	0
27	**COAL**, *yard band coal-seam*	3	0
28	White sandy fireclay ...	3	0
29	Grey sandstone	3	0
30	Sandy shale	4	9
31	**COAL**	0	9
32	Fireclay		
33	White sandstone		
34	Grey sandstone		
35	Blue shale		
36	Ironstone bed, with parting		
37	Black shale		
38	Dark fireclay		
39	Grey sandstone		
40	Ironstone bed, with parting		
41	Strong blue shale		
42	Ironstone, with parting .		
43	Shale		
44	Strong grey sandstone ...		
45	Hard sandstone		
46	Shale		
47	Dark-coloured shale		
48	Light-blue shale		
49	Black shale		
50	**COAL**		
51	Fireclay		
52	**COAL**		
53	Fireclay		
54	Shale		
55	Blue shale		
56	**COAL**, *little main coal-seam*		
57	Fireclay		
58	Blue sandstone		
59	Blue shale, with ironstone beds		
60	Light-blue shale		
61	Black sandstone		
62	**COAL**		
63	Fireclay		
64	White sandstone		
65	Blue shale		
66	**COAL**, *lickbank coal-seam*		
	Total		3

* The section below this point is that of the Ellen pit, Bullgill.

Appendix C.

14.—*Section taken near the bridge over the river Ellen.*

Description of Strata.	Thickness of Strata. Ft.	In.
Blue shale	13	7
COAL	2	9
Fireclay	0	11
COAL	0	6
Fireclay	1	0
COAL	1	0
Fireclay	1	4
COAL	0	3
Fireclay	0	6
Grey shale	42	8
Red shale	0	2
Grey sandstone	7	5
Red sandstone	2	3
Blue shale	0	2

No.	Description of Strata.	Thickness of Strata. Ft.	In.
15	Red sandstone	5	11
16	Light-blue shale	0	3
17	Red and yellow sandstone ...	12	7
18	Blue shale	1	4
19	Red and grey sandstone ...	2	9
20	White sandstone	0	6
21	Blue shale	2	11
22	Red sandstone	11	9
23	Yellow sandstone	8	5
24	White sandstone	0	6
25	Red sandstone	1	2
	Total	122	7

15.—*No. 5 Bore-hole, Bolton.*

Red shale	5	0	
Brown sandstone	2	8	
Blue and brown shale ...	5	3	
Grey sandstone	0	4	
COAL	2	6	
Fireclay	2	0	
Blue shale	10	0	
Black shale	6	0	
Sandstone	1	0	
COAL	0	6	
Light-coloured fireclay ...	3	6	
Brown fireclay	2	0	
Brown and grey shale ...	2	9	
Blue shale	10	0	
Brown sandstone	24	2	
Brown shale	6	0	
White sandstone	0	7	
Brown sandstone ...	4	4	
Dark-grey fireclay	2	6	
Light-coloured fireclay ...	3	0	
Blue shale	4	0	
Grey shaly sandstone ...	5	0	
Brown shale	3	9	

24	Light-grey shale	2	5
25	Brown and grey shale ...	9	0
26	Blue shale	5	0
27	Brown sandstone	5	5
28	Grey sandstone	0	6
29	Grey shale	3	5
30	Brown shale	2	6
31	Blue and grey shale	9	0
32	Blue shale	6	0
33	Light-coloured shale ...	8	4
34	Grey shaly sandstone ...	3	7
35	Dark-grey shale	2	2
36	Light-grey sandstone ...	0	8
37	Dark-grey shale	1	0
38	Light-blue shale	8	6
39	COAL	1	0
40	Light-grey shale	1	8
41	Brown sandstone	2	0
42	Brown and grey sandstone...	7	5
	Total	186	5

16.—*No. 8 Bore-hole, near Waverbank Farmhouse.*

Red and brown shale ...	7	0	
White and brown sandstone	9	6	
Brown shale	10	6	
Dark-coloured shaly sandstone	16	0	
Light-coloured shaly sandstone	10	0	
Brown and white sandstone	27	0	
Brown sandstone	10	0	
Red and white shale ...	2	0	
Brown sandstone	3	9	
Brown and grey sandstone...	11	0	
Brown and white sandstone	8	0	
Brown and grey shale ...	2	0	
Brown and white sandstone	2	0	

14	Brown and grey sandstone...	31	0
15	Brown and white sandstone	11	6
16	Brown and grey shale ...	17	0
17	Brown sandstone	17	0
18	Red shale	1	0
19	Brown and blue shale ...	6	0
20	Red shale	1	0
21	Brown and grey sandstone...	41	0
22	White sandstone	6	6
23	Brown sandstone	11	0
24	Brown and white sandstone	2	6
25	Brown shale	16	0
26	Brown and grey shale ...	3	0
27	Brown shale	11	0
28	Blue shale	2	0

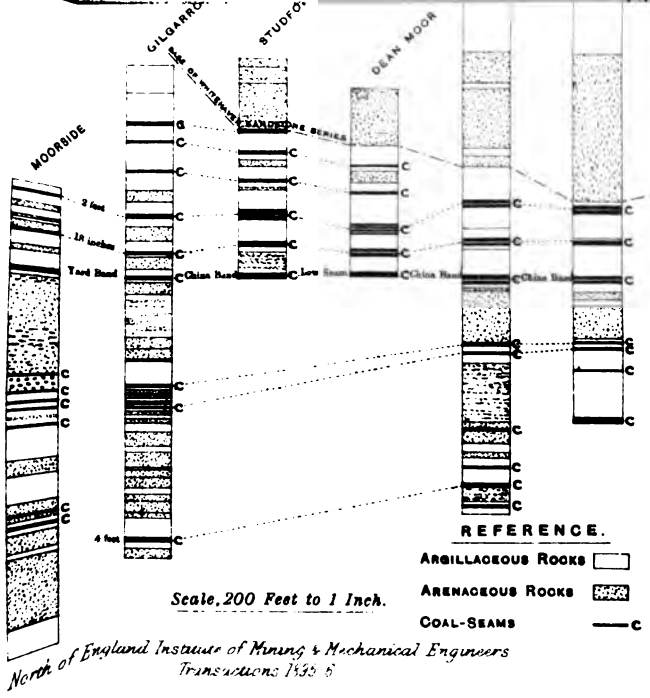
No.	Description of Strata.	Thickness of Strata. Ft.	In.
29	Brown and blue shale ...	18	0
30	Black shale	0	6
31	Dark-coloured shale ...	1	8
32	Brown sandstone	2	0
33	Brown and blue shale ...	10	6
34	White sandstone	1	0
35	Brown and blue shale ...	9	0
36	Blue shale	6	0
37	White sandstone	1	6
38	Blue shale	3	10
39	**COAL**	0	2
40	Fireclay	4	0
41	Grey sandstone	0	9
42	Blue shale	4	0
43	Grey sandstone	1	9
44	Blue shale	10	4
45	**COAL**	0	8
46	Fireclay	0	6
47	Grey sandstone	2	0
48	Blue shale	1	0
49	Dark shale and **COAL** ...	0	3
50	Fireclay	2	0
51	Grey and brown sandstone...	12	6
52	Blue shale	8	11
53	Black shale		
54	Fireclay		
55	Grey sandstone ...		
56	Blue shale		
57	**COAL**		
58	Fireclay		
59	Grey sandstone ...		
60	**COAL**		
61	Fireclay		
62	Blue shale		
63	White shale		
64	**COAL**		
65	Dark shale		
66	**COAL**		
67	Black shale		
68	**COAL**		
69	Fireclay		
70	Light-blue shale ...		
71	Black shale		
72	Brown and grey sandston		
	Total, but the base not reached ...		

The meeting then closed.

Transactions 1895 6

To illustrate Mr J. D. Kendall's Paper on "The Whitehaven Sandstone Series."

REFERENCE.

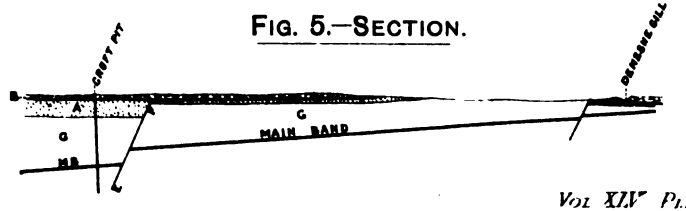


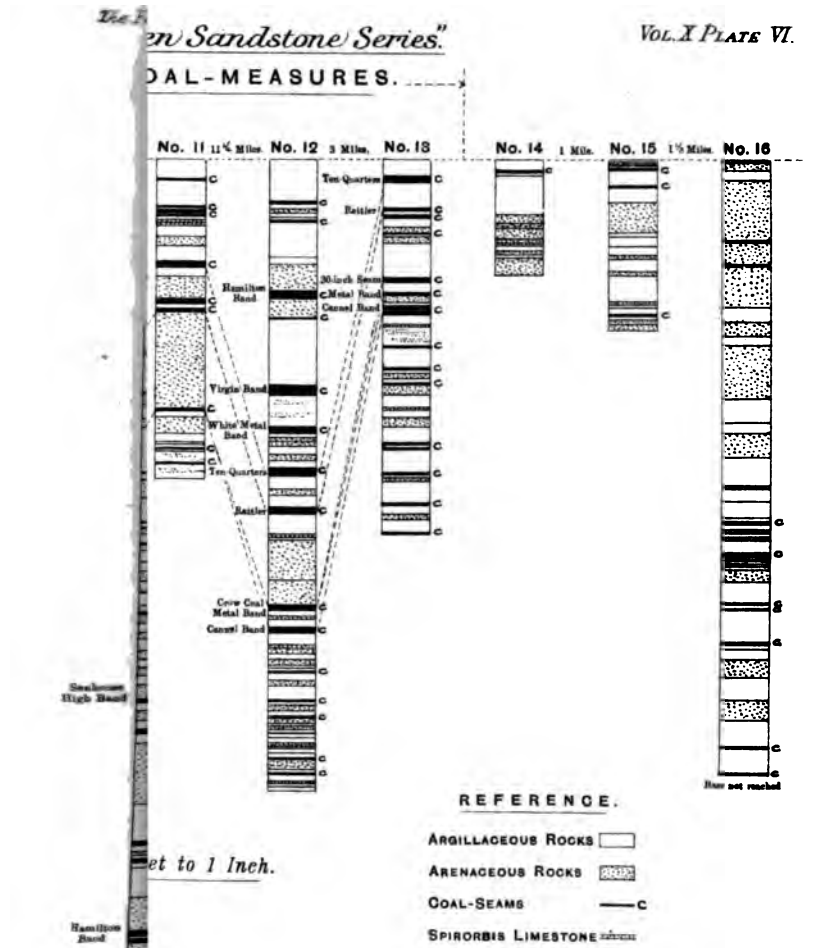
North of England Institute of Mining & Mechanical Engineers
Transactions 1895 6

REFERENCE.

D. ST. BEES SANDSTONE.
C. MAGNESIAN LIMESTONE.
B. BRECCIA.
A. WHITEHAVEN SANDSTONE SERIES.
G. MIDDLE COAL-MEASURES.

FIG. 5.—SECTION.





et to 1 Inch.

FIG. 6.

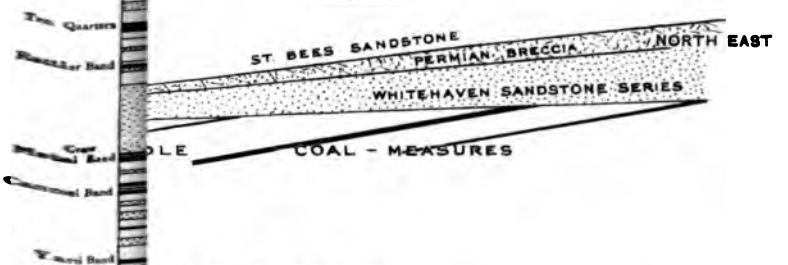
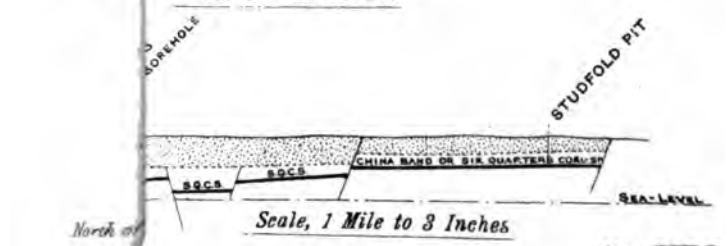


FIG. 8—SECTION.



Scale, 1 Mile to 3 Inches

THE FEDERATED INSTITUTION OF MINING ENGINEERS.

ANNUAL GENERAL MEETING,
HELD IN THE HALL OF THE HEAD-QUARTERS OF THE FIRST SHROPSHIRE AND STAFFORDSHIRE ARTILLERY VOLUNTEERS, HANLEY,
SEPTEMBER 18TH, 1895.

MR. W. N. ATKINSON, RETIRING PRESIDENT, IN THE CHAIR.

The SECRETARY read the Annual Report of the Council as follows :—

THE SIXTH ANNUAL REPORT OF THE COUNCIL.

In submitting the sixth Annual Report to the members of the societies connected with The Federated Institution of Mining Engineers, the Council is pleased to congratulate the members upon the success that has attended the formation of the Institution.

The desirability of the formation of such an Institution was initiated by the late Mr. Nicholas Wood in his first presidential address to the North of England Institute of Mining and Mechanical Engineers.

In May, 1854, a meeting of representatives from the coal-mining districts was held in London, and a suggestion was made for the formation of a society which should afford a means of communication between the various mining districts, and enable each district to acquaint itself with the superior or peculiar practices of the others, the representatives being of opinion that most valuable results would follow from such a means of circulating the mining knowledge of each district.

The late Sir George Elliot proposed, in 1868, that the various mining institutions should be amalgamated, so as to obtain a more general recognition of the importance and value of the profession of a mining engineer.

Mr. John Daglish, in 1886, suggested a scheme of federation, confined to the publication of joint transactions to the general advantage of the mining institutes.

The late Mr. Theo. Wood Bunning, the secretary to the North of England Institute of Mining and Mechanical Engineers, in 1887, pointed out* the desirability of establishing an Imperial Mining Institute, to which

* "The Mining Institutions of Great Britain," *Trans. N. E. Inst.*, vol. xxxvi., page 167.

the local mining institutes should be federated. He was of opinion that the existing institutes, although of considerable importance, were provincial associations, and that there was no institution representing mining engineers in their entirety; that their arrangements for publishing were inconvenient; and that the mass of valuable information published in their transactions was divided and rendered difficult of reference.

After Mr. Bunning's paper had been widely circulated a representative meeting was held in London, on June 6th, 1888. His suggestions were received with favour by many of the mining institutes, and it was decided that each should appoint representatives who should draft a scheme detailing the scope of the proposed Federated Institution. At a further meeting in London, on March 14th, 1889, the draft proposals were agreed to, and The Federated Institution of Mining Engineers was formed, at that time consisting of the Chesterfield and Midland Counties Institution of Engineers; the Midland Institute of Mining, Civil, and Mechanical Engineers; the North of England Institute of Mining and Mechanical Engineers; and the South Staffordshire and East Worcestershire Institute of Mining Engineers. The North Staffordshire Institute of Mining and Mechanical Engineers joined in July, 1891, and the Mining Institute of Scotland in July, 1893.

The Federated Institution of Mining Engineers is intended to promote a more general recognition of the status of mining and metallurgical engineering as scientific professions; to supply reliable information and advice to the Government upon the practical requirements of legislation relating to these professions; and to promote the advancement of the sciences of geology, mining, metallurgy, engineering, and their industrial applications, by the interchange of opinions, by the reading of papers, and by discussions.

The members receive the papers read at the meetings of the Federated Institutes, and participate in the two general meetings of the Federated Institution of Mining Engineers, held in each year in the various mining districts of the United Kingdom, and in one held annually in London. In addition, a meeting of the students and associates is held annually, when an essay is read upon a selected subject, and visits made to mines, etc. These considerable advantages would otherwise not have been obtained, except at greatly increased cost to individual subscriptions to each of the institutes.

The prosperity of the Institution would be materially enhanced if the members would use every endeavour to extend its membership, and more especially, if those who may be interested in kindred societies, would

exert their influence in favour of federation. By these means the power of the Institution would become more effective, and the value of its *Transactions* greatly enhanced.

The following table exhibits the progress of the Institution since its formation :—

Year.	No. of Members.	No. of Non-Federated.	Total.
1889-90	1,189	50	1,239
1890-91	1,187	9	1,196
1891-92	1,415	19	1,434
1892-93	1,533	19	1,552
1893-94	2,068	123	2,191
1894-95	2,210	109	2,319

The status of membership has been carefully considered, and the Council have suggested to the Federated Institutes the desirability of adopting a classification of their members in accordance with Bye-law 8 of this Institution. It is anticipated that this Bye-law will be generally adopted before the end of the current year.

General meetings of members have been held during the year in the North of England, in South Staffordshire, and in London, and the members may be congratulated on the excellence of the papers communicated at these meetings.

Arrangements were made during the year for a three days' Students Meeting, which was recently held under the auspices of the North of England Institute of Mining and Mechanical Engineers. The meeting proved very successful, and the reading of the prize essay on "The Prevention of Accidents in Mines," by Mr. Austin Kirkup, was followed by an interesting discussion.*

The attendance of the members at the General Meetings has been satisfactory, although their residences are scattered in all parts of the United Kingdom and abroad.

The thanks of the Institution have been conveyed to the gentlemen who kindly allowed their works and mines to be visited by the members during the period of the meetings.

Prizes have been awarded to the writers of the following papers, printed in volumes vi. and vii. of the *Transactions* :—

"A Contribution to our Knowledge of Coal-dust." By Dr. P. Phillips Bedson and Mr. W. McConnell, Jun.

"The Transmission of Power by Compressed Air." By Prof. John Goodman.

"The Friction of, or Resistance to, Air-currents in Mines." By Mr. D. Murgue.

* *Trans. Fed. Inst.*, vol. x., page 1.

"Result of an Experimental Research into Choke-damp Poisoning, with Special Reference to Oxygen as a Restorative." By Dr. W. Ernest Thomson.

Presidential addresses have been delivered during the year to the members of The Federated Institution of Mining Engineers, by Mr. W. N. Atkinson; the Midland Institute of Mining, Civil, and Mechanical Engineers, by Mr. John Nevin; the North of England Institute of Mining and Mechanical Engineers, by Mr. Thomas Douglas; the North Staffordshire Institute of Mining and Mechanical Engineers, by Mr. Edward B. Wain; and the South Staffordshire and East Worcestershire Institute of Mining Engineers, by Mr. H. C. Peake.

The *Report* (Parts 1 and 2) of the Proceedings of the Flameless Explosives Committee of the North of England Institute of Mining and Mechanical Engineers has been recently published, and the Council have made arrangements by which it can be procured at a low cost by members of the Institution.

Prof. A. W. Rücker contributed a valuable paper on "The Magnetic Survey of Great Britain," containing a summary of the results of the complete magnetic survey recently carried out by Messrs. Rücker and Thorpe. Mr. James Henderson also contributed a note on "Magnetic Declination in Mines."

The following papers have been read upon geology:—

"The Discovery of a Concealed Ridge of Supposed Cambrian Rocks under the New Red Sandstone of Netherseal, near Ashby-de-la-Zouch, Leicestershire." By Prof. Edward Hull.

"The Search for Coal Over the Eastern Boundary-fault of the South Staffordshire Coal-field, with Especial Reference to the Sinking at Hamstead Colliery, and the Working of the Thick Coal-seam." By Mr. F. G. Meachem.

"The Copper and Tin Deposits of Chotá-Nagpore, Bengal, India." By Mr. Robert Oates.

"The Extension of the West Cumberland Coal-field Southward and Northward under the St. Bees Sandstone." By Mr. R. Russell.

"Remarks on the Banket Formation at Johannesburg, Transvaal." By Mr. A. R. Sawyer.

"Lithographic Stone and its Uses." By Mr. Edmund Spargo.

"The Occurrence, Mode of Working, and Origin of Petroleum in Lower Alsace." By Dr. L. van Werveke.

"British Guiana Gold-fields." By Mr. E. P. Wood.

Mining engineering has been dealt with in the following papers:—

"The Blackwall Tunnel." *Anon.*

"Electric Haulage by the Main-and-tail Rope System." By Mr. E. J. Bailey.

"Sinking with Rock-drills." By Mr. Frank Coulson.

"Gob-fires in Longwall Workings, with Special Reference to the Yard Seam." By Mr. Arthur Hassam.

"A Modified Form of Longwall Working as Applied to Thin Seams of Moderate Inclination." By Mr. John Heath.

"An Underground Endless-rope at the Moston Colliery, Manchester." By Mr. H. Richardson Hewitt.

"The Working of Hæmatite in the Whitehaven District." By Mr. J. M. Main.

"The Mining of the Softer Ores of Furness." By Mr. H. Mellon.

"Electric Coal-cutting at Glenclelland Colliery." By Mr. G. A. Mitchell.

"Walling and Sinking Simultaneously with the Galloway Scaffold." By Mr. John Morison.

"The Ross Rock-drill." By Mr. J. MacEwan Ross.

"The Garforth Collieries, with Special Reference to the Failures of the Tubbing and Inundations which occurred in 1872 and 1883." By Mr. R. Routledge.

"A Detaching-hook used at the Sinking Pit at the Old Oaks Colliery." By Mr. E. W. Thirkell.

"Notes on the Practicability of Working the Thin Coals of North Staffordshire by the adoption of Mechanical Appliances." By Mr. B. Woodworth.

The following papers have been contributed relative to mechanical engineering:—

"Pumping-engine Velocity Diagrams." By Mr. Dugald Baird.

"Overhanging Beam Pumping-engine." By Mr. John G. Barclay.

"The Barclay Crown-valve Exhaust-gear." By Mr. John G. Barclay.

"Hargreaves Balanced Slide-valves." By Mr. James Bowers.

"Hargreaves Piston." By Mr. James Bowers.

"Timber Bridges and Viaducts." By Mr. Morgan W. Davies.

"Description of Pumping-engines at the Hatton Pumping-station of the Staffordshire Potteries Waterworks Company." By Mr. T. M. Favell.

"Remarks on Winding-engines." By Mr. A. M. Grant.

"Railway-waggon Axle-boxes and the Mode of Manufacturing them from Steel-plate." By Mr. J. Newton.

"Water-tube Boilers." By Mr. Allan Stirling.

"Designs for Pump-valves." By Mr. H. Wormald.

The following papers have been communicated on the subject of mine ventilation, safety-lamps, coal-dust, etc.:—

"The Change of Composition Produced in Air by Flames and by Respiration." By Prof. Frank Clowes.

"The Limiting Explosive Mixtures of various Combustible Gases with Air." By Prof. Frank Clowes.

"The Effect of an Obstruction in the Air-way of a Mine." By Mr. T. L. Elwen.

"Explosions in Nova Scotian Coal-mines." By Mr. Edwin Gilpin, Jun.

"Investigations on the Composition, Occurrence, and Properties of Black-damp." By Messrs. John Haldane and W. N. Atkinson.

"Description of the Arrangements at the Maybach Colliery (Germany) for Watering Coal-dust." By Mr. C. Haarmann.

"Saving of Life from After-damp, Smoke, or Fumes in Mines." By Mr. Simon Tate.

"Safety-lamps used at the Oaks Collieries." By Mr. E. W. Thirkell.

"Watering Underground Roadways, and a Lighted Lucifer Match at the New Oaks Collieries." By Mr. E. W. Thirkell.

"An Outburst of Gas at Mitchell Main Colliery." By Mr. W. Washington.

"The Shaw Gas-tester for Detecting the Presence and Percentage of Fire-damp and Choke-damp in Coal-mines, etc." By Mr. Joseph R. Wilson.

The subject of inland navigation was considered in several valuable papers read at the South Staffordshire meeting, by gentlemen specially competent to deal with the subject. Mr. Lionel B. Wells placed a valuable "Map of Canals and Navigable Rivers of England and Wales" at the disposal of the Council, and it is reproduced as Plate XXV., of vol. viii. of the *Transactions*. The Council are of opinion that these papers and the accompanying discussions afford valuable information on the important subject of the inland navigations of Great Britain. The papers were as follow:—

"The Relative Progress of Railways and Waterways, and the Methods Suggested by its Consideration for Promoting the Arrested Development of the Latter." By Mr. Urquhart A. Forbes.

"Inland Navigation, with Special Reference to the Birmingham District." By Mr. L. F. Vernon-Harcourt.

"The Comparative Conditions and Costs of Transport by Railway and Canal." By Mr. J. Stephen Jeans.

"The Severn Navigation, with Particular Reference to Recent Improvements." By Mr. E. D. Marten.

"Canals and their Improvements, more Particularly Applying to the London and Birmingham Trade." By Mr. W. Salt.

"Canals." By Mr. J. A. Saner.

"Canals." By Mr. Lionel B. Wells.

"Birmingham and its Canal-connexions with the Seaports." By Mr. W. H. Wheeler.

The use of explosives has been the subject of the following papers:—

"Improvements in Exploders for Shot-firing." By Mr. Harold Bonser.

"Mining Explosives." By Prof. Vivian B. Lewes.

"Experiments with Explosives." By Messrs. E. W. Thirkell, A. A. Atkinson, and Matt. Hall.

"Experiments with Explosives." By Mr. Winkhaus.

The preparation of minerals has been considered in the following papers:—

"Sampling." By Mr. T. Clarkson.

"Banking-out, Screening, and Mechanical Arrangements for Direct Sorting and Packing of Coal." By Mr. William Hay.

"Modern Coal-tipplers." By Mr. J. J. Prest.

"Historical Notes on Early Plans for Coal-washing." By Mr. F. J. Rowan.

"The Murton Coal-washer." By Mr. W. O. Wood.

Electrical subjects have been considered in the following:—

"Electric Haulage by the Main-and-tail Rope System." By Mr. E. J. Bailey.
"Continuous-current Dynamos and Motors." By Mr. L. W. de Grave.
"Electric Coal-cutting at Glenclelland Colliery." By Mr. G. A. Mitchell.
"The Design, Efficiency, and Application of Electric Motors for Transmission of Power in Mines." By Mr. W. C. Mountain.
"Electric Transmission of Power." By Mr. Alexander Siemens.

Metallurgy has been treated of in the following papers :—

"The Gold-milling Process at Pestarena, Italy." By Mr. A. G. Charleton.
"The MacArthur-Forrest Process." By Mr. John McConnell.
"The Mexican or Patio Process of Reducing Silver Ores." By Mr. John Nevin.
"The Stetefeldt Furnace." By Mr. C. A. Stetefeldt.

The miscellaneous papers have been :—

"The Brunsviga Calculating-machine." *Anon.*
"Barometer, Thermometer, etc., Readings for the Year 1894." By Mr. M. Walton Brown.
"The Brunck Coke-oven and System for the Recovery of Bye-products." By Dr. R. Brunck.
"The Semet-Solvay Coke-oven." By Mr. John H. Darby.
"Improvements in Brick-kilns." By Mr. R. W. Moore.
"Colliery Cost-sheets." By Mr. J. J. Prest.
"Damage done by Lightning to the Surface-works at Garforth Colliery." By Mr. R. Routledge.
"Engineering Heliography, or the Sun-print Copying of Engineering Drawings." By Mr. B. H. Thwaite.

The members may be congratulated upon the number and varied nature of the papers communicated to the Federated Institutes, and the council trust that similar contributions will be forwarded as liberally as heretofore for insertion in the *Transactions*.

The "Notes of Papers on the Working of Mines, Metallurgy, etc., from the Transactions of Foreign Societies and Foreign Publications," have been continued, and have proved of great value to the members.

The number and bulk of the papers have necessitated the *Transactions* being printed in two volumes (viii. and ix.), and it is hoped that these have been received with satisfaction by the members.

In considering the history of the mining institutes since the formation of the North of England Institute of Mining and Mechanical Engineers in 1852, their influence may be clearly recognized in improved methods of mining and metallurgy, in the progress of technical education, and in advanced knowledge of geology and other sciences.

The years since 1852 have been marked by great progress in the quantities of mineral wrought and metals produced, by the great decline in the prices of the products of the miner and metallurgist, and especially

by the great changes and improvements in the conditions of the mines and of the miners. There can be no hesitation in recognizing that a great part of these improvements are due to the formation and development of the mining institutes.

During this period, examinations have been instituted for mine managers' certificates, improved explosives have become a necessity, mechanical appliances on the surface have replaced the underground furnace as a means of ventilation, electricity has been introduced as a motive power, etc. The introduction of many of these improvements has been expedited by the discussions conducted by the mining institutes, despite the small proportions of the members who were in attendance.

As in the past, the future development of the mining institutes depends, therefore, upon the *Transactions* being maintained at a high standard of excellence.

The purpose of general meetings of the members, of visits to works and mines, and of the communication of papers is not completely fulfilled unless there be ample discussions. Discussion proves the merits and trustworthiness of a paper, brings the experience of the speakers to a focus, and often elicits additional information from the writer. In this way, a large amount of information, which is often full of suggestions is made available, and would otherwise not be recorded. The value of oral and written discussion is dependent upon the members, and the value of the *Transactions* is also dependent upon the care with which each of the members revises his share of the papers or discussions. Much may be said for or against oral or written discussions. The former has the advantage of securing the attendance of members desirous of hearing and giving opinions which could not otherwise be obtained; and generally it will be found that the plan of oral discussion, followed by written remarks, will draw into the discussion persons who are unable to be present. The printed discussions greatly enhance the value and interest of the *Transactions*, but it should, however, be remembered that unnecessary increase in the volume of discussion involves proportionately great expense and labour in arranging the revision of the oral and written remarks. This work also entails lengthy correspondence, and requires careful attention, oversight, and discriminating intelligence, and members should do all in their power to assist the Secretary by prompt and careful revision or condensation of the proof of their share in the proceedings.

BOOKS, ETC., ADDED TO LIBRARY.

Association of Engineering Societies, Articles of Association adopted December, 1880.

Beneké, George, Explosives employed in Coal-mines, their Composition, Safety, and Behaviour towards Coal-dust and Pit-gas. The New Safety Explosive Westphalite.

Bickerton, A. W., Some Recent Evidence in Favour of Impact (extract from the Transactions of the New Zealand Institute, vol. xxvi., 1893).

Birmingham and Bristol Channel Improved Navigation, 1890.

Borings at Culford, Winkfield, Ware and Cheshunt. By W. Whitaker and A. J. Jukes-Browne. (From the Quarterly Journal of the Geological Society, August, 1894).

Boucher, Arthur S., Nature and Strength of Timber.

British Guiana, Report of the Commissioner of Mines for the year 1893-94.

British Society of Mining Students, vol. xvii., Nos. 1, 2, 3, 4.

Catalogue of the Michigan Mining School, 1892-94.

Claudet, Arthur C., Mining and Milling at the Mesquital del Oro Gold-mine, State of Zacatecas, Mexico, 1895.

Coal-dust an Explosive Agent: As shown by an Examination of the Camerton Explosion, with 7 plates. By Donald M. D. Stuart.

Cory Brothers, British Coal Trade and Freight Circular (Monthly) from July, 1894, to June, 1895.

Electric Transmission and Distribution of Power. The Electrical Company, Limited.

Engineering and Mining Journal, vol. lviii., Nos. 4-26; vol. lix., Nos. 1-26; vol. lx., Nos. 1 and 2.

Frazer, Malcolm A. C., Western Australian Year-book for 1893-94.

Geological Survey of New South Wales, Palæontological Memoirs, i., v., vii., and viii.; Geological Memoirs, i.-v.; Annual Reports of the Department of Mines and Agriculture, 1891-94; Records of the Geological Survey, vol. i., Nos. 1 and 3; vol. ii., Nos. 2-4; vol. iii.; vol. iv., Nos. 1-3.

Hoskold, H. D. Mémoire Général et Spécial sur les Mines, etc., dans la République Argentine.

Hoskold, H. D., Republica Argentina. Catálogo Official de las Meustras de Minerales Exhibidas en la Sección Argentina Annexa a la Exposición de Paris, 1889.

House, John, Blasting in Coal-mines, Explosives and Detonators. A Lecture delivered in the Wigan Mining and Technical School, March, 1895.

Illinois Mining Institute, Journal, vol. iii., Nos. 1 and 2.

India, Report of the Inspector of Mines for the Year ending 30th June, 1894. By James Grundy, Inspector of Mines in India.

Institution of Mining and Metallurgy, vol. i., Nos. 1-4; Laws and List of Members, 1894; vol. ii.; vol. iii., Nos. 1 and 2.

Journal of the Franklin Institute, 1895, vol. cxxxix., Nos. 1 to 6.

Journal of the General Mining Association of the Province of Quebec, vol. i., 1891-93.

Karuth, Frank, A New Centre of Gold Production, Notes on the Philippine Islands (Reprint from the Mining Journal, 1894).

Kingdon, Abraham, A Statement Concerning the Charge of Conspiracy made by the Prime Minister of Madagascar.

L'Industria Minéra en Chile, 1890.

Liversidge, A., The Mineral Resources of New South Wales.

Manchester Association of Engineers, Inaugural Address by the President, Sir E. Leader Williams, January 12th, 1895.

Mines, 1894. Summaries of Statistics relating to Mines and Minerals obtained by H.M. Inspectors of Mines.

Mining Handbook (and Map) to the Colony of Western Australia. By Harry Page Woodward.

Mining Society of Nova Scotia, Transactions, vol. iii.,

National Boiler and General Insurance Company, Limited. Chief Engineer's Report, 1894.

New Zealand, Papers and Reports relating to Minerals and Mining, 1894.

Northumberland and Durham Miners' Permanent Relief Fund. Thirty-third Annual Report, from January 1st to December 31st, 1894.

Patent No. 2387, February 15th, 1887. Specification of Edward John Lloyd and William Salt. New or Improved Machinery or Apparatus for Transferring Ships and Boats and other vessels from one level to another on Ship and other Canals and Rivers.

Pennsylvania State College, Mining Bulletin, vol. i., Nos. 1-6.

Report of the British Association for the Advancement of Science, 1894 (Oxford).

Stetefeldt, C. A., The Inaccuracy of the Commercial Assay for Silver, and of Metallurgical Statistics in Silver-mills, with Special Reference to the Treatment of Roasted Ores by Amalgamation and by the Russell Process. Author's Edition, 1894.

Spon's Engineers' and Contractors' Illustrated Book of Prices of Machines, Tools, Ironwork, and Contractors' Material, 1895-96.

Spon's Engineers' Diary and Year-book, 1895.

Society of Arts, Journal, May 24th, 1895, containing "The Dressing and Metallurgical Treatment of Nickel Ores." By A. G. Charleton.

South Wales Institute of Engineers, Transactions, vol. xix., Nos. 1-4.

Vorkommen, Gewinnung und Entstehung des Erdöls im Unter-Elsass. Dr. L. van Werveke.

Walcott, Charles D., The United States Geological Survey.

Weeks, Joseph D., Petroleum in 1893 (extract from Mineral Resources of the United States, 1893).

Whitaker, W., Suggestions on Sites for Coal-search in the South-east of England (extract from the Geological Magazine, November, 1890).

Wilkinson, W. F., History of the Holmbush, Redmoor, and Kelly Bray Mines, situated near Callington, East Cornwall, with several Sections of the Workings (Reprint from the Mining Journal, 1895).

Willing's British and Irish Press Guide, 1895.

EXCHANGES.

British Association for the Advancement of Science.

British Society of Mining Students.

General Mining Association of the Province of Quebec.

Illinois Mining Institute.

Institution of Mining and Metallurgy.

Manchester Geological Society.

Mining Society of Nova Scotia.

New South Wales, Minister of Mines.

Revue Universélle des Mines, de la Métallurgie, etc.

South Wales Institute of Engineers.

The Local Institutes in Account with The Federated Institution of Mining Engineers, for the Year Ending July 31st, 1895.

Dr.	No. of Members. Federated.	No. of Members. Non-Federated.	Balance due at the beginning of the year.	Amounts falling Due during the Year. Calls made during the year.	Excerpts.	Transactions, Reducing Plates, etc.	Totals.
			£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Chesterfield and Midland Counties Institution of Engineers ...	327	...	2 14 0	277 19 0	8 18 5	4 16 8	294 8 1
Midland Institute of Mining, Civil, and Mechanical Engineers	233	...	25 5 0	198 1 0	5 2 1	2 6 8	230 14 9
Mining Institute of Scotland	390	100	0 16 8	381 10 0	13 7 6	2 13 4	398 7 6
North of England Institute of Mining and Mechanical Engineers	939	...	28 4 0	798 3 0	42 6 6	23 9 8	892 3 2
North Staffordshire Institute of Mining and Mechanical Engineers	192	9	23 3 2	167 14 0	6 17 3	2 16 8	200 11 1
South Staffordshire and East Worcestershire Institute of Mining Engineers...	116	...	29 1 10	98 12 0	0 8 9	19 6 8	147 9 3
Totals	2,197	109	109 4 8	1,921 19 0	77 0 6	55 9 8	2,163 13 10

Cr.	Amounts Paid during the Year. Balance from previous year.	Calls.	Excerpts.	Transactions, Reducing Plates, etc.	Totals.	Balance due at July 31st, 1895.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Chesterfield and Midland Counties Institution of Engineers ...	2 14 0	268 12 0	8 4 3	4 15 8	284 5 11	10 2 2
Midland Institute of Mining, Civil, and Mechanical Engineers	25 5 0	196 7 0	4 5 0	2 6 8	228 3 8	2 11 1
Mining Institute of Scotland	0 16 8	381 10 0	9 7 11	0 10 0	392 4 7	6 2 11
North of England Institute of Mining and Mechanical Engineers	28 4 0	796 15 8	42 6 6	23 9 8	890 15 10	1 7 4
North Staffordshire Institute of Mining and Mechanical Engineers	23 3 2	152 18 0	1 17 10	0 6 8	178 5 8	22 5 5
South Staffordshire and East Worcestershire Institute of Mining Engineers	29 1 10	40 7 6	0 8 9	...	69 18 1	77 11 2
Totals	109 4 8	1,836 10 2	66 10 3	31 8 8	2,043 13 9	120 0 1

Dr. THE TREASURER IN ACCOUNT WITH THE FOR THE YEAR

	£ s. d.	£ s. d.
July 31, 1894—		
To Balance at Bank	89 6 0	
„ „ in Treasurer's hands	83 7 6	
		172 13 6
To Subscriptions for year ending July 31, 1893—		
Federated—		
South Staffordshire and East Worcestershire Institute of Mining Engineers	9 16 0	
		9 16 0
To Subscriptions for year ending July 31, 1894—		
Federated—		
Chesterfield and Midland Counties Institution of Engineers	1 14 0	
Midland Institute of Mining, Civil, and Mechanical Engineers	24 5 0	
North of England Institute of Mining and Mechanical Engineers	6 16 0	
North Staffordshire Institute of Mining and Mechanical Engineers	20 12 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	12 1 0	
		65 8 0
To Subscriptions for year ending July 31st, 1895—		
Federated—		
Chesterfield and Midland Counties Institution of Engineers	268 12 0	
Midland Institute of Mining, Civil, and Mechanical Engineers	196 7 0	
Mining Institute of Scotland	331 10 0	
North of England Institute of Mining and Mechanical Engineers	796 15 8	
North Staffordshire Institute of Mining and Mechanical Engineers	148 8 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	40 7 6	
		1,782 0 2
Non-Federated—		
Mining Institute of Scotland	50 0 0	
North Staffordshire Institute of Mining and Mechanical Engineers	4 10 0	
		54 10 0
To Local Publications and Authors' Copies—		
Chesterfield and Midland Counties Institution of Engineers	1893-94. 8 4 3	1894-95
Midland Institute of Mining, Civil, and Mechanical Engineers	4 5 0	
Carried forward	12 9 3	2,084 7 8

FEDERATED INSTITUTION OF MINING ENGINEERS. **Cr.**
ENDING JULY 31, 1895.

July 31, 1895.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
By Printing—												
Transactions, Vol. VII., printing	272	10	4									
„ „ VII., plates	43	12	0									
				316	2	4						
„ „ VIII., printing	429	13	1									
„ „ VIII., plates	170	18	6									
				600	11	7						
„ „ IX., printing	.....											
„ „ IX., plates	6	10	0									
				6	10	0						
							923	3	11			
Excerpts, Vol. III.				1	9	6						
„ „ V.				2	0	6						
„ „ VI.				2	4	6						
„ „ VII.				35	17	0						
„ „ VIII.				94	19	6						
							136	11	0			
Circulars				... ..			19	6	7			
Proofs of Papers for General Meetings				.....			18	1	0			
										1,097	2	6
By Stationery, etc.				.....			41	7	5			
„ Addressing Transactions, Circulars, etc.				.....			12	8	3			
„ Postages—Calendars				4	3	7						
„ „ Circulars				9	9	6						
„ „ Correspondence				16	18	8						
„ „ Transactions				227	8	6						
							258	0	3			
„ Insurance of Transactions				.....			2	10	0			
„ Binding—Library				6	0	3						
„ „ Sundries				1	4	6						
„ „ Transactions				21	3	9						
							28	8	6			
„ Reporting—London General Meeting				.....			10	16	6			
„ Incidental Expenses				.....			14	7	8			
„ Expenses of General Meetings				.....			4	15	4			
„ Petty Cash...				.....			6	3	4			
„ Salaries, Wages, etc.				.....			442	6	6			
„ Indexing Transactions				.....			9	13	4			
„ Travelling Expenses—Secretary				43	10	7						
„ „ „ Treasurer				2	17	6						
							46	8	1			
										877	5	2
Carried forward										1,974	7	8

Dr. THE TREASURER IN ACCOUNT WITH

	£ s. d. 1893-94	£ s. d. 1894-95.	£ s. d.
Brought forward	.....	12 9 3	2,084 7 8
Mining Institute of Scotland	.....	9 7 11	
North of England Institute of Mining and Mechanical Engineers	.....	42 6 6	
North Staffordshire Institute of Mining and Mechanical Engineers	1 11 2	1 17 10	
South Staffordshire and East Worcestershire Institute of Mining Engineers	2 4 10	0 8 9	
The Federated Institution of Mining Engineers	0 12 5	19 7 11	
	4 8 5	85 18 2	90 6 7
To Sales of Transactions, etc.—			
	1893-94.	1894-95.	
Chesterfield and Midland Counties Institution of Engineers	1 0 0	3 5 8	
Midland Institute of Mining, Civil, and Mechanical Engineers	1 0 0	2 6 8	
Mining Institute of Scotland	0 16 8	.....	
North of England Institute of Mining and Mechanical Engineers	21 8 0	19 9 8	
North Staffordshire Institute of Mining and Mechanical Engineers	1 0 0	0 6 8	
South Staffordshire and East Worcestershire Institute of Mining Engineers	3 0 0	.....	
Members, etc.	.....	113 13 3	
	28 4 8	139 1 11	167 6 7
To Reducing Plates—			
	1893-94.	1894-95.	
Chesterfield and Midland Counties Institution of Engineers	.....	1 10 0	
Mining Institute of Scotland	.....	0 10 0	
North of England Institute of Mining and Mechanical Engineers	.....	4 0 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	2 0 0	.....	
	2 0 0	6 0 0	8 0 0
To Advertizements	... ...	...	463 14 10
			£2,813 15 8

THE FEDERATED INSTITUTION OF MINING ENGINEERS.—*Continued.* Cr.

	£	s.	d.	£	s.	d.	£	s	d.
Brought forward							1,974	7	8
By Advertisements—Agreement Stamps	1	0	0						
„ „ Commission	100	14	0						
„ „ Printing	2	0	0						
„ „ Sundries	0	1	0						
				103	15	0			
„ Prizes, Vols. VI. and VII.				20	0	0			
„ Translations of Papers				9	7	0			
„ Abstracts of Foreign Papers, Vols. VII. and VIII. ...				27	10	0			
„ Barometer Readings, etc.				8	6	0			
„ Calendar				13	4	0			
„ Solicitor's Charges				0	10	6			
							182	12	6
							2,157	0	2
„ Mining Institute of Scotland, amount refunded for Excerpts				.....			10	6	2
„ Balance at Bank				607	15	8			
„ „ in Treasurer's hands				38	13	8			
							646	9	4
							£2,813	15	8

THE FEDERATED INSTITUTION OF MINING

Liabilities.

	£	s.	d.	£	s.	d.
Sundry Creditors—						
Advertizements Paid in Advance	22	0	10			
Printing, etc.	720	0	0			
Postage of Transactions	40	0	0			
Abstracts of Foreign Papers	50	0	0			
Barometer Readings	5	0	0			
Prizes for Papers, Vols. VIII. and IX.	20	0	0			
Index, Vol. IX.	6	0	0			
Travelling Expenses, Treasurer	4	0	0			
				867	0	10
Balance of Assets over Liabilities				948	7	7

I have examined the above Balance Sheet with the books and vouchers relating thereto, and certify that in my opinion it exhibits a correct view of the affairs of the Institution.

I have accepted the Asset "Transactions in Stock" as valued by the officials of the Institution.

JOHN G. BENSON,
Chartered Accountant.

Newcastle-upon-Tyne,
September 5th, 1895.

£1,815 8 5

ENGINEERS.—BALANCE SHEET, JULY 31, 1895.

Assets.

	£ s. d.	£ s. d.
Balance at Bank	607 15 8	
„ in Treasurer's hands	38 13 8	
		646 9 4
Subscriptions Unpaid, Year ending July 31, 1895—		
Chesterfield and Midland Counties Institution of Engineers	9 7 0	
Midland Institute of Mining, Civil, and Mechanical Engineers	1 14 0	
North of England Institute of Mining and Mechanical Engineers	1 7 4	
North Staffordshire Institute of Mining and Mechanical Engineers	14 16 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	58 4 6	
		85 8 10
Excerpts Unpaid—		
Chesterfield and Midland Counties Institution of Engineers	0 14 2	
Midland Institute of Mining, Civil, and Mechanical Engineers	0 17 1	
Mining Institute of Scotland	3 19 7	
North Staffordshire Institute of Mining and Mechanical Engineers	4 19 5	
Members, etc....	8 3 8	
		18 13 11
For Reducing Plates—		
North Staffordshire Institute of Mining and Mechanical Engineers		0 10 0
Transactions Sold—		
Chesterfield and Midland Counties Institution of Engineers	0 1 0	
Mining Institute of Scotland	2 3 4	
North Staffordshire Institute of Mining and Mechanical Engineers	2 0 0	
South Staffordshire and East Worcestershire Institute of Mining Engineers	19 6 8	
		23 11 0
Advertizements unpaid		210 13 4
		985 6 5
Transactions in Stock—		
4 Volumes at 12s.	2 8 0	
8 „ 10s.	4 0 0	
4 „ 9s. 9d.	1 19 0	
6 „ 8s. 3d.	2 9 6	
728 „ 7s.	254 16 0	
10 „ 5s. 3d.	2 12 6	
2,035 „ 4s.	407 0 0	
3,097 Parts at 1s.	154 17 0	
		830 2 0
		£1,815 8 5

ELECTION OF OFFICERS.

The SECRETARY announced the following elections by the Council :—

PRESIDENT.

MR. GEO. A. MITCHELL.

VICE-PRESIDENTS.

MR. W. N. ATKINSON.	MR. J. T. FORGIE.	MR. H. C. PEAKE.
MR. E. BAINBRIDGE.	MR. W. E. GARFORTH.	MR. FRED. J. ROWAN.
MR. W. COCHRANE.	MR. GEORGE LEWIS.	MR. A. SOPWITH.
MR. J. DAGLISH.	MR. G. MAY.	MR. W. SPENCER.
MR. T. DOUGLAS.	MR. J. NEVIN.	MR. A. L. STEAVENSON.
	MR. E. B. WAIN.	

AUDITOR.

MR. JOHN G. BENSON, Newcastle-upon-Tyne.

TREASURER.

MR. REGINALD GUTHRIE, Neville Hall, Newcastle-upon-Tyne.

The CHAIRMAN had very much pleasure in introducing Mr. Mitchell as his successor in the office of President. Mr. Mitchell would find that there was much work in connexion with the office, but with the assistance of the Secretary that work had, in his own case, been rendered as easy as possible, and he had no doubt that Mr. Mitchell would find it the same in his case also. It had been a very great pleasure to him to act as President of The Federated Institution of Mining Engineers, and he would continue to do all in his power to forward its interests.

The PRESIDENT, on taking the chair, said he esteemed it a very high honour to occupy that position, regarding it as the chief honour which could be conferred upon a mining engineer in Great Britain. His only regret was that he did not possess the qualifications which the former Presidents had for the office. He assured the members that he would do all he could to advance the welfare of the Institution. His first duty as President was to propose a vote of thanks to Mr. Atkinson, the retiring President. He belonged to a family well known among mining engineers, and had himself done much original investigation, some of the results of which he had placed before the Institution. He had been a worthy President, and was one who could speak with authority on many subjects.

The motion was carried with acclamation, and was briefly acknowledged by Mr. ATKINSON.

STUDENTS' ESSAYS.

The SECRETARY read the following report :—

The Committee appointed to select the prize paper on "The Prevention of Accidents in Mines" beg to report that they received nine papers from the following gentlemen :—Mr. E. Aston Allport, Medomsley, R.S.O., County Durham; Mr. Walter Newton Drew, Rockingham colliery, near Barnsley; Mr. G. C. Fowler, Cliff House, Cinder Hill, Nottingham; Mr. W. D. Harbitt, 34, High Street West, Wallsend-upon-Tyne; Mr. Fred King, Cramlington Village, Northumberland; Mr. Austin Kirkup, Murton colliery, near Sunderland; Mr. Norman Nisbet, Tantobie, County Durham; Mr. Algernon Noble, Broomhill colliery, Northumberland, and Mr. Jonathan Severs, East Stanley, R.S.O., County Durham.

The Committee have pleasure in stating that the whole of the papers were of a commendable character, and we agree that Mr. Austin Kirkup's paper is the best,* that Mr. W. N. Drew's paper is the second best, and that the papers by Messrs. E. A. Allport and A. Noble are so evenly balanced that we can only bracket them for third and fourth places respectively.

GEORGE LEWIS.
ARTHUR SOPWITH.
W. N. ATKINSON.

July 13th, 1895.

Mr. C. E. DE RANCE read the following paper on "The Depth to Productive Coal-measures between the Warwickshire and Lancashire Coal-fields" :—

* *Trans. Fed. Inst.*, vol. x., page 2.

THE DEPTH TO PRODUCTIVE COAL-MEASURES BETWEEN THE WARWICKSHIRE AND LANCASHIRE COAL-FIELDS.

By CHAS. E. DE RANCE, Assoc. Inst. C.E., F.G.S., F.R.M.S., F.R.G.S.

The *Report* of the Royal Coal Commission* contains the Proceedings of the Committee appointed to enquire into the "Probability of Finding Coal under the Permian, New Red Sandstone, and other Superincumbent Strata," an enquiry which lasted from October 10th, 1866, to June 23rd, 1869.

The following communication is intended as a comment on the information then elicited as regards our knowledge in 1895 (a period of nearly thirty years) of the area described in the title. The real business of the committee commenced at the meeting on March 13th, 1868, when Sir Roderick Murchison and Mr. Woodhouse stated it should be a serious consideration to the committee and the Commission whether they should not put down experimental boreholes for coal in favourable spots in England.

Mr. Woodhouse suggested that maps and sections made for the purposes of the Commission ought to be carefully preserved for the public in some place where the public could have access to them. It was shown by Mr. Woodhouse that no detailed information which could be construed into a breach of confidence of pledges given to individuals who had supplied information need be broken. Neither of these valuable suggestions were carried out, but a very large number of borings have been made for the purposes of water-supply and mineral-trials since that date, and most of these have come under the writer's consideration as Secretary and Reporter of the Circulation of Underground Waters Committee of the British Association for the Advancement of Science between 1874 and the present year, but much still remains to be learnt.

It was pointed out to the Royal Commission, by one of the largest coal-owners of South Staffordshire that the Commission should urge the expenditure of £200,000 or £300,000 on borings, but this was largely discountenanced by Mr. Dickinson, H.M. Inspector of Mines, who thought the coal trade would not approve, and, acting on his suggestion

* Vol. ii., pages 413 to 525.

the Commission did not so recommend, and the main question, as Mr. Geddes pointed out in 1868, "is there, or is there not, coal here and there," still remains an unsolved quantity.

Dr. (then Mr.) Edward Hull, in his evidence before the Royal Commission,* recognized that in the Forest of Wyre and at Bridgenorth, the Lower Carboniferous rocks are wholly absent, and the Upper Coal-measures, with few and unimportant coal-seams, rest on ancient rocks, and the area is almost beyond that of the margin of the submerged Carboniferous area, while in the Abberley Hills the Permian(?) rests direct on the Silurian, and are beyond the original margin. He pointed out that the Warwickshire coal-field is a lip of the old original coal-basin, intervening and extending further southward than usual between the Silurian barrier west of Birmingham and the Cambrian area west of Charnwood Forest. Dr. Hull considers that this ancient barrier extends to the mouth of the Wash. Dr. Hull also pointed out the existence of another east-and-west barrier, which, he believed, separates the North Staffordshire coal-field from that of Cheshire beneath the red rocks, and further causes the Permian rocks overlying the Coal-measures to be disposed in distinct basins or areas. He states that—

I have been much impressed with the extreme dissimilarity of the Permian rocks of the two areas. This dissimilarity is so great that it is almost impossible to suppose that they were deposited in the same basin; and when I was endeavouring to ascertain whether there were any grounds for supposing that the Carboniferous rocks had been thrown up in such a manner as to form separate basins for the deposition of the Permian rocks of the two areas, I found that on the east side of the plain of Cheshire, in the neighbourhood of Congleton, we have the Yoredale beds and the Carboniferous Limestone brought up, so as to separate the coal-field of North Staffordshire from that of Cheshire; and though originally I, along with other geologists, attributed this to the existence of a great fault which I estimated at an enormous amount of down-throw on the west, I now think that that fault has been over-estimated, and is not sufficient to account for the absence of the whole of the Carboniferous beds down to the Mountain Limestone in that neighbourhood. Besides this, we know from the researches of [the late] Mr. Binney that there are Permian beds resting unconformably on the Yoredale rocks a few miles north of Leek, which shows that the upheaval and the denudation of the Lower Carboniferous rocks in this district took place before the Permian period. . . . . When we cross the Cheshire plain to the west, we also find at the southern margin of the Flintshire coal-field Lower Carboniferous rocks brought up partly along the line of a fault. Now, that fault and that upheaval, I consider, in all probability as referable to the pre-Permian period; and I think that it is exceedingly probable that all along a line, which may be drawn from Macclesfield on the east to the neighbourhood of Hope, in Flintshire, to the west, the Lower Carboniferous rocks have been brought up in such a manner as to have formed what I was looking for, namely,

* *Report*, vol. ii., page 437.

a barrier between the Permian area of South Lancashire and Cheshire, and th
Permian area of the Midland counties and Shropshire. . . . . At Hope, to th
south-west of Chester . . . the Millstone Grit and Lower Carboniferous be
[are] brought up and overlaid directly by the New Red Sandstone;——th
formation resting in an unconformable position on the Lower Carboniferous be
That is the position where this barrier commences, which, as I suppose, stre-tc
underneath the Cheshire plain.*

Dr. Hull assumed that coal exists under a large area to the nort
the barrier, including the peninsula of the hundred of Wirral, and poi
out that the Denbigh coal-seams appeared to extend persistently
ward, and the North Staffordshire coal-field westward, and consi
that south of the barrier an absolute continuity of the measures obtai

Recent investigations have thrown a flood of light upon the relat
of the various subdivisions of the red rocks in the Midland count
The numerous borings made between Liverpool and Manchester du
the past twenty years, which the writer had annually recorded in Reports of the Circulation of Underground Waters Committee of British Association for the Advancement of Science, prove that classification of Dr. Binney in 1842 still stands, with the follow modifications as to thickness, as regards the valley of the Mersey:—

	Trias.		Thickness. Dr. Binney. Feet.		Author. Feet
1	*a*. Red and variegated marls ...	Keuper series	?	...	—
	b. Gypsum and saliferous marls		800	...	1,764
	c. Waterstones		440	...	708
2	Bunter series		600	...	1,600
3	*a*. Red and variegated marls and magnesian limestone		210	...	210
	b. Lower New Red Sandstone		120	...	750

In 1854, Dr. Hull subdivided the Bunter series into three subdivisions, a middle pebble-bed, separating an upper from a lower variegated or mottled sandstone. Later investigations prove the lower mottled sandstone to really belong to the base of the true Permian, and it is naturally overlain by the fossiliferous Permian marls, containing the shells of mollusca, indicating a fauna closely related, according to Dr. Geinitz, to that of southern Russia.

The true Permian rocks of South Lancashire and North Cheshire are remarkable for their extreme variability in thickness over the most limited areas, varying 600 feet in 3 miles, due to several contemporaneous denudations, which are marked by lines or seams of conglomerates containing jasper, quartz-pebbles, and lydian-stones. The true Permian rocks rest

* *Report*, pages 439 and 440.

indiscriminately on all members of the Carboniferous system, which had been upheaved, plicated, and denuded before the overlying Permian rocks were deposited.

No evidence has arisen to shake Dr. Hull's view, that a pre-Permian ridge of old rocks formed the southern margin of the Lancashire and Cheshire Permian rocks, and nowhere in England or Wales has an assemblage of Permian fossils been found south of that line, Triassic pebble-beds resting direct on the Millstone Grit, both in Flintshire and Staffordshire, and there is still every reason to believe that Dr. Hull's central ridge traverses a portion of Cheshire, and renders it unproductive of coal. On the other hand, if it be admitted that the lower mottled sandstone is really the lower bed of the true Permian, the neighbourhood of Eastham, in the Cheshire hundred of Wirral, should be, in the future, the site of a very important coal-field, situated as it is at the portals of the Manchester ship-canal, on the banks of the navigable estuary of the Mersey, and at a depth of less than 1,000 feet. So far as the Permian cover is concerned, as regards the depth of Coal-measures to be penetrated to commercial coal, we have no evidence, but 6 miles to the west the pebble-beds of the Trias rest direct on the thick seams of the Neston coal-field, which is capable of general correlation with the middle Coal-measures of the opposite shore of the river Dee, in Flint and Bagillt.

In South Lancashire, the exact position of the coal-seams formerly worked at Croxteth Park is doubtful, but in any case they are directly overlain by Permian and New Red Sandstones, without the intervention of the Upper Coal-measures, which were formerly well seen at Whiston, near Liverpool, and in the Levenshulme railway-cutting, near Manchester, described by Mr. Brockbank and the writer,* in which occurs 443 feet of green, purple, and mottled marls, with about a dozen beds of limestone, of which the thickest is 4½ feet. The limestones occurring in the upper Coal-measures in Britain appear to have been first noticed by Mr. Francis Looney in his key to Mr. Elias Hall's geological map, who stated early in the century that fish-remains occurred in them at Ardwick and Bradford, near Manchester. The first detailed description of them was given by the late Prof. Williamson in 1836,† and at the Liverpool meeting of the British Association for the Advancement of Science in

* *Proceedings of the Literary and Philosophical Society of Manchester*, 1891, vol. iv., pages 282 and 339.

† *London and Edinburgh Philosophical Magazine*, series 3, vol. ix., pages 241-348

1837, the first held in Lancashire, at which Dr. Dalton and the late E Philip Egerton were vice-presidents. In that year Sir Roderi Murchison found the annelid *Spirorbis* (*Microconchus*) *carbonarius*, the limestone of the Shropshire and Manchester Upper Coal-measure In 1864, Dr. Hull described the calcareous development of the Upp Coal-measures as the maximum of Britain, no less than six beds o limestone occurring with an aggregate thickness of 15 feet; and stated t the Permian rocks overlie unconformably, other limestones may occur, surmise the Levenshulme cutting has proved to be correct; he estimate the depth from the lower limestone to the Openshaw coal-seams, in th Bradford district, as 600 feet, which is probably correct.

In the centre of Manchester, at Messrs. Fryers & Co.'s sugar-work purple marls with *Spirorbis* limestones were reached at 420 feet an continued to 546 feet, but the beds below were not proved. At Clayto Vale, east of Manchester, purple shales with eleven beds of limestone an two of calcareous ironstone occurred below these Permian rocks, betwee 1,042 and 1,300 feet from the surface; the beds were red at the bottor of the borehole, the whole of the cores of which were examined by th writer.

West of Manchester, at Patricroft, under the Permian rocks, M Binney described the following section :—

	Ft.	In.
Red and grey shales (Upper Coal-measures)	10	0
Hæmatite band	2	0
Shales and sandstone	174	0
Slack Lane coal-seam	1	10
Shales and sandstone	1,006	0
Worsley 4 feet coal-seam	4	0

In a boring, at Monton, in the same neighbourhood, the writer identifi the calcareous ironstone, which must underlie a large area under th Manchester ship-canal, and contains 22 to 26 per cent. of metallic iro It is worthy of note, that here only 1,188 feet of measures intervei between the canal and the Worsley 4 feet coal-seam, and that westwar the depth is probably less.

In calculating the depth to the productive Coal-measures, thanks the deep borings at Liverpool for the purposes of water-supply, and search of coal and other minerals in Northwich, by the Salt Unio Limited, the knowledge of the thickness of the Triassic rocks is complet The latter borings probably commenced about 400 feet below the base the Lias, and through the courtesy of the company the writer w allowed to carefully watch the progress of the work, and made typic

collections of the cores for the Museum of Practical Geology, London; the Owens College Museum, Manchester; and the Brunner Salt Museum, Northwich. The following is an abstract of the measures passed through :—

Strata.	Depth. Ft.	In.	Thickness of Strata. Ft.	In.	Ft.	In.
Glacial drift	31	9	31	9	31	9
Keuper marls with rock-salt	412	2	382	5		
Keuper marls with gypsum	1,078	10	664	8		
Keuper or upper sandy marls	1,293	9	214	11		
Upper Keuper sandstone...	1,469	4	175	7		
Keuper or lower sandy marls	1,795	8	326	4		
					1,763	11
Water-stones, Frodsham beds, Basement beds } Keuper	2,022	1	226	5		
	2,190	4	188	3		
	2,504	3	313	10		
					708	6
Upper mottled sandstone, Bunter ...	2,610	4	106	2		

Estimating the very least probable thickness of the beds beneath, no less than 1,300 feet would have had to have been traversed by the boring to have reached the Carboniferous rocks, or a total depth from the surface of 3,810 feet, or 1,060 feet deeper than might have been expected from the facts and information known before the commencement of the experiment. Looking to the effect of pressure and high temperature, the low prices ruling of coal, which, without an extraordinary expansion of trade that there is no reason to anticipate, will remain at their present figure until the coal-supply becomes scarce, the depth of 3,810 feet will render coal-workings beneath the New Red plain of Cheshire unremunerative, even if no other measures intervene, and other circumstances are favourable. But there is every reason to believe that a thick series of purple marls and Red Sandstones, without coals of commercial importance overlie the productive Coal-measures, to the south of the old barrier indicated by Dr. Hull, these measures being considered by him as of Permian age deposited in a separate basin from that of the fossiliferous Permian beds of the Mersey basin. But recent trials in various directions in the Midland counties point to these beds being really referable to the upper portion of the Carboniferous formation, and that they belong to that portion of the Upper Coal-measures which lies above the *Spirorbis* limestone, and is not less than 1,200 feet in vertical extent.

Sections in the Manchester ship-canal, in the Runcorn area, prove that the maximum thickness known in Britain of the upper mottled sandstone is there reached, which is not less than 600 feet. As regards the Pebble-beds of the Bunter series, railway-sections, and borings for water in Liverpool, also give a maximum record, and the beds are

certainly not less than 1,000 feet in thickness. The phrase or name derived from the loose conglomerates of Middle Bunter age of Cann Chase, where they are easily dug with a spade, and this type also holds North Staffordshire, but in Cheshire, and still more in Lancashire, t rock forms hard building-stone; in the case of the walls of Chester shows most clearly the chisel-marks imprinted in the days of the Ror occupation. Pebbles are comparatively rare, and in the upper b generally wholly absent.

A deep boring for coal, put down at Hazelgrove, near Stockport, the Manchester Freeholders' Company, at a site suggested by the writ carries on the record. The abstract of the section is as follows :—

	Thickness of Strata. Ft.	In.	Depth of Strata. Ft.	In.
Glacial drift	80	0	80	0
Bunter Pebble-beds	30	0	110	0
Permian marls and sandstones ...	913	0	1,023	0
Coal-measures (chiefly red)	471	7	1,494	7
Coal-seam and shale	2	0	1,496	7
Dark shale: ironstone-nodules ...	11	5	1,508	0
Coal-seam	2	2	1,510	2
Dark and grey measures	110	10	1,621	0
Coal-seam	1	0	1,622	0
Parting	0	4	1,622	4
Coal-seam	4	0	1,626	4
Shales: ironstone-nodules	32	3	1,658	7
Coal-seam	1	11	1,660	6

The dip varied from 7 to 11 degs.: the measures do not corresp with the adjacent Poynton coal-field, and are probably on a higher hori but below the upper Coal-measures. This boring is very important supporting the evidence obtained in driving an experimental tunnel w wards from Lord Vernon's Park pit at Poynton, where after pass through a large fault, which had the effect of burning the shales, th feet coal-seam being reduced to a cinder, and the ironstones altered so to resemble jasper. Dr. Hull pointed out in 1866 that whether or this be the red rock fault, an unknown coal-seam 3 feet thick was reac on the downthrow side, which supported the view held by Mr. Binney 1841, who stated "I call the point where the New Red Sandstone for tion abuts against the Coal-measures the fault, for the exact line of dislocation in the latter strata we can never hope to determine since edges have been worn down, and afterwards covered with New Red Sa stone," and a careful study of his works leads the writer to believe he c sidered the so-called "red rock fault" more the limit of overlap of New Red on the Coal-measures than an actual dislocation, and the writ

own investigations lead him to believe that Mr. Binney was entirely correct. This view was held by the late Sir Philip Egerton, who first informed the writer that an anticlinal axis occurs at Asbury, near Congleton, in the limestone underlying the Millstone Grit, and that he was of opinion that the westward rapid dip brought in a coal-field beneath the Cheshire plain at moderate depths. Unfortunately there is at present no evidence whether the various subdivisions of the Triassic rocks do or do not taper off against the Carboniferous slope as they do further south, but the Alsager boring tends to show that they do not, and in that case the depth to productive Coal-measures in South Cheshire, North Staffordshire, and Shropshire is far greater than was anticipated by Sir Andrew Ramsay.

The *Spirorbis* limestone was first identified in the North Shropshire and North Wales coal-field by the late Mr. D. C. Davies* who discovered it in the Pentre Isaf ravine, near Wynnstay. Examination of the specimens submitted by him to Mr. Etheridge and Mr. Daniel Jones

ABSTRACT SECTION (FROM MR. DAVIES' PAPERS) OF THE DENBIGHSHIRE COAL-FIELD.

		Feet.
BUNTER PEBBLE-BEDS—		
Dark red thick-bedded sandstone, with occasional bands of small pebbles, and beds of thin marls near the base (Whittington boring and banks of the river Dee, North Shropshire) ...		630
Rock		
Shales		
Flannog new coal-seam...		
Red and blue binds ...		
Coedyrallt rock (calcareous concretions) ...	Ifton or St. Martin's coal-field ...	225
Morlas main coal-seam...		
Blue shales (limestone concretions) ...		
Little Morlas coal-seam		
Red, white, and mottled marls, with thin rock bands (calcareous)		
Thin coal-seam		540
Red, white, yellow, and brown rock (*Calamites*)		
Green and grey rocks, and conglomerates		375
Dark shales (*Spirorbis* limestone near base)		240
Cefn rock, shales, and coal		300
Cefn coals to lower yard coal-seam		710
Lower yard to Chwarch coal-seam		240
Strata to Millstone Grit		405
Total		3,665

* *Quarterly Journal of the Geological Society of London*, 1877, vol. xxxiii., page 10.

confirmed his opinion, the former identifying not only *Spirorbis carbonarius* but *Cytherea Scoto-Burdigalensis;* this was in 1873, and in February, 1876, the limestone was passed through at No. 3 pit, Ifton Rhyn collieries, on the Shropshire side of the river Dee, 3 miles south-east of Pentre Isaf, where it was first seen.

A very interesting paper was recently read to the Geological Society, London, by Mr. J. Crosbee Cantrill, on the occurrence of *Spirorbis* limestone and thin coals in the so-called Permian rocks of the Wyre Forest, with considerations as to the systematic position of the Permians of Salopian type.* Mr. Cantrill points out that in the West Bromwich district a coal-seam, 10 inches in thickness with a fireclay of 3 feet 8 inches, occurs between 170 feet of Red Sandstone and marls and over 511 feet of the same, and states that Prof. Hull considered them red Coal-measures, and Prof. Jukes as Permian rocks containing a coal-seam.

The Sandwell Park sinking, commenced in 1876, proved a limestone, 1 foot thick, with *Spirorbis pusillus,* Marten.† It is evident that Sir Roderick Murchison when he re-discovered this annelid in the Shrewsbury coal-field was unaware of its discovery by Mr. Marten, and of his actually figuring the shell and naming the same, but the first discoverer evidently thought that it was a mollusc.

The *Spirorbis* limestone at Sandwell Park occurred at 369 feet from the surface, in 575 feet of red and purple sandstone and marls, 200 feet from their base, and Mr. Cantrill points out that the ordinal *Spirorbis* limestone of the district occurs in blue and yellow clay orange and olive sandstones and grits, about 50 feet below the red be and he states that only 670 feet of rocks intervene between the base the red rocks and the thick coal-seam at Sandwell Park colliery, while less than 900 feet occur at Halesowen, pointing to two distinct horizo of *Spirorbis* limestone.

Mr. Cantrill says that since the work of Prof. Jukes was publish fresh sinkings in the South Staffordshire district have proved that the rocks must all be regarded as of Upper Coal-measure age, becau (1) their contained fossils have an Upper Coal-measure facies ; (2) th contain bands of limestone characterized by the presence of *Spirorbis pusillus;* (3) those parts of the series which have not yielded Coal-measure fossils are apparently similar lithologically to those parts whi have yielded such fossils; (4) there is no known stratigraphical bre

* *Quarterly Journal*, vol. li., page 528.

† Formerly *Spirorbis carbonarius.* The genus *Spirorbis* was Mr. Lamarck's in 1818, the genus *Microconchus* Sir R. Murchison's in 1837; but the shell itself was recognized by Mr. Marten in 1809 at Chesterfield, and named *Conch.* (*Helicites pusillus.* (*Pet. of Derb.*, 1809, vol. ii., pages 2 and 3.)

between the fossiliferous and the non-fossiliferous parts of the red series; (5) the only marked breaks are at the base and the summit of the red series; (6) the break at the base is locally great, but is elsewhere imperceptible.

The late Prof. Jukes showed in his *Memoir on the South Staffordshire Coal-field* that a band of Silurian elevated rocks extended across from Shropshire, through South Staffordshire, to Warwickshire, and formed dry land in this area, at the time that Carboniferous Limestone and Millstone Grit were elsewhere deposited, and he regarded the beds underlying the Warwickshire coal-field as of the age they have been re-discovered to be by Prof. Lapworth in 1882, who found fossils of Cambrian age in the shales of which Prof. Jukes wrote in 1853, after speaking of the gentle westerly dip which the Silurian strata of the South Staffordshire coal-field had assumed before the deposition of the Coal-measures:— "That this gradual rise to the east was continued yet further in that direction beyond the bounds of our [South Staffordshire] district is rendered probable by the fact that rocks still older than the upper Silurian (perhaps older than any Silurian) appear in the Warwickshire and Leicestershire coal-fields, with the Coal-measures resting directly upon them." The truth of this theoretical surmise has since been established by the borings made between the Warwickshire coal-field and the Charnwood Forest rocks, which have proved Prof. Jukes' ridge to extend from Montgomeryshire to that remarkable area where Keuper marls rest direct on Archæan rocks.

The line of the margin of these ancient lands rising above the waters of the Lower Carboniferous seas appears to roughly correspond to an area of depression beneath the sea during the Upper Coal-measure era.

Through the kindness of Mr. Meachem, of Hamstead colliery, near Birmingham, the writer has had the opportunity of examining the whole of the specimens found in the Hamstead sinking. The sinking commenced in Permian marls and conglomerates, closely resembling those penetrated at the Coventry Waterworks. These were underlain by a thin band of limestone, without *Spirorbis* remains, at 558 feet from the surface, underlain by yellow sand, with Coal-measure ferns from 600 to 627 feet. "Fish-eyed" markings commenced at a depth of 729 feet from the surface, becoming smaller in depth, and disappearing at 1,020 feet. They occurred wholly in the Upper Coal-measures, which ceased to be stained red with iron at a depth of 939 feet from the surface. The shales at 1,008 feet contained ripple-marks, raindrops, and drifted wood. At 1,024 feet occurred the *Spirorbis* limestone, 8 inches in thickness.

Below the *Spirorbis* limestone occurred purple marls, and at 1,4 feet from the surface a very curious conglomerate, which is evidently t base of the Upper Coal-measures, and points to erosion of the Mid Coal-measures beneath.

Immediately above the first coal-seam were shales containing mari shells, as *Productus*, *Goniatites*, *Leda*, and others. This marine fau corresponds to that occurring in the chance pennystone of Coalbrookd and the river Tame beds, near Ashton-under-Lyne, discovered Prof. Green.

The investigations of Mr. W. J. Harrison on the west of the Warwi shire coal-field, and those of Prof. Lapworth on the east, have relegated supposed Lower Coal-measures, to the era of the Lower Silurian Ling flags, and thus reduced the thickness of the Coal-measures from 3,000 to less than half that amount. Apparently conformably underlying quasi-Permian rocks, and 150 feet below their base, occurs the *Spiro* limestone, of a thickness (as described by Mr. Howell in 1859) of 2 feet. He noticed another higher horizon of limestone without *Spiro* remains, which would appear to correspond to that met with at Hamst colliery. The conformity of the quasi-Permian and Upper Coal-meas in Warwickshire appears to be established, but it is very doubtful wh the Upper Coal-measures and the beds below are conformable. Leicestershire the Upper Coal-measures consist of coarse grits, re unconformably on the Middle Coal-measures.

Very numerous sinkings have been made in the quasi-Permian o neighbourhood of Coventry, Nuneaton, and Atherstone, and they forcibly bring out the enormous amount of denudation that took between the formation of the Warwickshire coal-field and the overl Keuper sandstones. It will be remembered that in the Lancashire North Cheshire area, the Triassic rocks reach their maximum deve ment, whilst, on the other hand, the highest Coal-measure deposits absent. The following table gives the relative occurrences :—

	North Warwickshire. Feet.	Lancashire and Cheshire. Feet.
Keuper marls...	650	1,800
Keuper waterstones	100	226
Keuper Frodsham beds	Absent	170
Keuper building-stones	3	320
Bunter upper mottled sandstone	Absent	400
Bunter pebble-beds	Absent	1,000
Permian marls	Absent	210
Permian sandstones	Absent	750
Midland Upper Coal-measures	1,000	Absent
Upper Coal-measures (*Spirorbis*)	670	1,200

As regards the thickness of the Keuper marls, the following sections disclose the rate and amount of southerly attenuation :—

Thickness.	From	Miles.	Direction.	To	Thickness.
Feet.					Feet.
—	Northwich (Marston)	38	S.E.	Chartley	552
—	" " ...	35	S.S.E.	Stafford Common ...	770
—	" " ...	82	S.S.E.	Stratford-on-Avon ...	604
—	" " ...	110	S.S.E.	Burford (Oxford) ...	291

At Burford, the entire thickness of the Red Sandstones between the Keuper marls and the Coal-measures (which consisted of fine-grained calcareous yellow sandstone and red and mottled marls) was only 37 feet. These were most certainly referable to the Keuper, and they show a much greater depletion of sandy material southwards than that affecting the marls. It is worthy of note that both in the Charnwood Forest area and that of the Mendip Hills the sandy deposits cease, and the Keuper marls alone overlap the ancient rocks.

In Warwickshire, the Bunter beds in the Nuneaton district, and the Keuper waterstones, rest transgressively on the quasi-Permian, which are strictly conformable to the *Spirorbis* limestone of the undoubted Coal-measures beneath and the Coal-measures themselves; whilst further east, towards Leicestershire, the Keuper marls rest direct on coal-bearing Coal-measures, occurring sporadically, or on the very ancient rocks, rising originally as islands, separating rocks of carbonaceous growth.

In the light of these investigations it will be seen that the late Sir Andrew Ramsay under-estimated the depth to commercial coal-seams in the Midland counties, more especially in the area of maximum development of the Trias formation; but the whole gist of the accumulated information tends to show the extreme variety of the conditions obtaining at any one point; further, that each small area must be judged and considered on its merits, and that without actual boring the judgment of the expert however experienced, may be at fault. It certainly might have been supposed, looking to the occurrence of the quasi-Permian beds in Denbighshire, North and South Staffordshire, and Warwickshire, in very considerable force, that they would have been present in the Sherbrook valley, Rugeley, but then 327 feet of Bunter pebble-beds rest direct on Coal-measures, and at the Huntingdon pumping station of the South Staffordshire water-works the same conditions obtained.

From these facts it appears that three series of rocks intervene between the Keuper marls and the commercial coal-fields of Lancashire and Warwickshire.

Proceeding from north to south, the Triassic group attenuate from t base upwards, the Bunter series being absent, the basement beds of t Keuper, though present, being only a few inches thick, the waterston and Keuper marls being much less than half their thickness. Proceedin from north to south, the true Permian is also found to be governed b the same conditions, and none occurs south of Dr. Hull's barrier in centra Cheshire; on the other hand, the coarse sandstone and conglomerates, th variegated and purple marls, with included bands of *Spirorbis* limestone are constantly absent proceeding from south to north of Dr. Hull' barrier, the Triassic pebble-beds constantly resting direct on the Middl Coal-measures, the extensive denudation that commenced with the firs appearance of the red dust at the close of the Carboniferous perio (ascribed by Mr. Binney to volcanic origin), continuing in great forc through the whole of the period between the formation of the upp commercial coal-seams and the deposition of the Triassic pebble-beds.

Mr. W. B. Scott (H.M. Inspector of Mines, Birmingham) observe that Mr. De Rance had not told them what he would like to do. N doubt what he would like to see done was the carrying out of the sugge tion made by a South Staffordshire coal-owner to the Royal Commissio referred to in the paper—that there should be an expenditure of £200,00 or £300,000 in borings for coal. He had recently visited some borin being made to ascertain if certain coal-seams continued from Rugeley i the direction of North Staffordshire, and to discover whether there wa any continuation of the coal-field to Derbyshire on one side and Warwick shire on the other.

Mr. J. H. Merivale deprecated asking for Government aid to con duct the borings, which should be made by the landowners at their ow expense.

Mr. John Vivian (Whitehaven) said that there was a tendency o the part of the landowners to develop their estates, but he did not kno whether that was altogether in the interests of the coal trade generally for there appeared to be an overplus of coal.

Mr. Herbert W. Hughes (Dudley) said that the mapping of area round the South Staffordshire coal-field as Permian when they were no Permian had retarded the development of that coal-field so long as area

in the known coal-field remained unworked. Probably coal existed continuously between the South Staffordshire and Warwickshire coal-fields, but whether or not at a workable depth was doubtful. The eastward extension of the South Staffordshire coal-field was complicated by the existence of ridges of Silurian rocks concealed by newer strata. He had recently described, at the Birmingham meeting of the Iron and Steel Institute, the discovery of one of these Silurian banks at Sandwell Park colliery, and had mentioned the fact that the thick coal-seam showed a tendency to split up in an easterly direction. These points had a great bearing on the economic value of the coal-seams in an easterly and south-easterly direction from the area already proved. Probably there was greater chance of success in tracing the coal-seams if the search were made from the Warwickshire side.

Mr. F. G. MEACHEM (Hamstead) wrote that it seemed highly probable that the Upper Coal-measures in the Midland counties were not conformable to the Lower Coal-measures, and there was clear evidence of unconformity at the Hamstead colliery, near Birmingham. A few years ago, a very careful survey of the district was made previous to the opening out of the Hamstead colliery in a south-easterly direction. Evidence of dislocation was diligently sought, but for miles the red rocks of the Upper Coal-measures and overlying Trias gave no indication of any serious faulting. Nevertheless, in the thick coal-seam workings, when roads were driven, great dislocations were found which would have been visible at the surface, if the upper beds had been deposited prior to the dislocation. Respecting the depth at which coal may be found in the district spoken of by Mr. De Rance, he (Mr. Meachem) was of opinion that the depth would be very great, being dependent upon the thickness of the Trias and of the Upper Coal-measures. From Hamstead colliery, in an easterly direction, the depth of the mines will become deeper until the upheaved Warwickshire field is reached. As a mining engineer, he (Mr. Meachem) thought that the probable depth to workable coal-seams would be about 2,000 feet, where the top bed of the Upper Coal-measures formed the surface; and where the Keuper Marls and New Red Sandstone formed the surface, the depth would vary from 2,400 to 3,000 feet. The thick coal-seam would be very difficult to work if the fire-clay floor and the soft roof of the South Staffordshire coal-field were found to extend into this new coal-field.

Mr. G. E. COKE asked whether there were any clear distinction between the Bunter and the Keuper sandstones, pebbles being found in both?

Mr. De Rance, in reply, said that the pebbles in the Bunter pebble beds were generally liver-coloured quartzites, which Mr. Jerome Harri of Birmingham, had carefully investigated, and found to be full of Carb fossils; on the other hand, the pebbles in the Keuper sandstones seldom altered sandstone or quartzite, but chiefly consisted of milky wh vein-quartz and occasionally of Lydian-stone. The Keuper basem beds alone are pebble-bearing, except at Waterloo, near Liverpool, wh a pebbly zone occurs just below the overlying Keuper marls. Keuper sandstones, when weathered, acquired a peculiar ashy colour, whereas the Bunter pebble-beds retained their purple colour any length of exposure. In the case of the Bunter pebble-beds, grains were so open that the spaces between were charged with wa which caused the Bunter to be a good water-bearing formation, where the edges of that formation were exposed, either in natural or artificial quarries, it often became coated with a growth of green m whereas in the case of the Keuper basement-beds, the grains generally cemented together by lime or baryta, and afforded no lodgmen water. He noted what Mr. Meachem had said as to the unconformabl of the red rocks of the Upper Coal-measures at Hamstead colliery on Middle (or productive) Coal-measures, and the dislocation and fract that had taken place in the latter before the deposition of the for That fact, he thought, gave an answer to Mr. H. W. Hughes' stric as to the Geological Survey being the means of preventing the search coal in that district, because they had mapped certain beds as Perm which were not Permian. If thick unproductive measures occu at all, it was commercially immaterial what they were called. isolated patches of Permian rocks in Lancashire were found resting u various members of the Carboniferous series. Near Blackburn, on Lancashire and Yorkshire railway, a small patch rested upon the denu and upturned edges of the Millstone Grit, the whole of the interver measures having disappeared. In the Warwickshire coal-field, Ke sandstone was found resting unconformably on unproductive C measures. Passing westward towards Wales, the Upper Coal-meas were found to first rest upon the Middle Coal-measures, then on Lower Series, next on the Carboniferous Limestone; then they transgressively over the Old Red Sandstone, and eventually rest u Silurian rocks.

The President moved a vote of thanks to Mr. De Rance for paper.

Mr. J. Blaikie seconded the motion, which was agreed to.

DISCUSSION UPON PROF. VIVIAN B. LEWES' PAPER ON "MINING EXPLOSIVES."*

Mr. A. H. Stokes, criticizing Prof. Lewes' argument that the use of explosives which give rise to carbon monoxide as a product of their combustion should be prohibited in dusty mines, because a small quantity of carbon monoxide rendered coal-dust and air highly explosive. If this be correct, the use of blasting-powder should be abolished from all dusty mines, for its residuum of combustion is stated to contain 42 per cent. of combustible products; but, according to the table on page 331, there were other explosives which gave off a large percentage of combustible products when detonated. Again, two of the most serious explosions for some time past had occurred in collieries where dynamite was used, and that explosive was stated to give off the least carbon monoxide. Two points in Prof. Lewes' paper were worthy of special notice, viz., the inferior quality of some gunpowder used in mines, and the explosive properties of carbon monoxide, especially in pits subject to gob-fires and those which were dusty.

Mr. M. Deacon said that he had read Prof. Lewes' paper with great interest, and thought it would add very greatly to the value of the *Transactions*. From a scientific point of view, the paper was no doubt very valuable, but he ventured to suggest that the commercial view of the question had not received the amount of consideration it deserved. He (Mr. Deacon) thought that Prof. Lewes dealt in rather too sweeping a manner with blasting-powder, which he proposed, without any qualification, to banish from use in mines, even where fire-damp was unknown, on the ground that it was capable of creating an explosion with coal-dust alone. The latter statement was also, perhaps, too sweeping, as much depended upon the quality of the coal-dust and its dryness as to whether it would be inflamed by a shot. He (Mr. Deacon) believed that there were many coal-dusts which would not ignite under the ordinary conditions of shot-firing in the mine. Then, again, if a dusty mine were properly watered or the dust removed, as required by the Coal Mines Regulation Act, it was difficult to see where the danger of using powder in such a case applied. In many instances, where powder was used for blasting coal, the danger of coal-dust did not exist, as the coal was not generally pulverized in the working-faces to a dust of such fine character as to

* *Trans. Fed. Inst.*, vol. ix., page 320.

render it inflammable. This condition of things was principally confi to haulage-roads where the slack and coal which fell from the tram transit became pulverized by the feet of horses and workmen travel along the roadways. This, of course, was not a hard-and-fast rule, t being some notable exceptions, such as some of the steam-coal collieri South Wales.

In the substitution of high explosives for powder, they did not seer get out of the difficulty of the risk of firing gas, from the fact that detonator used for firing the explosives very often gave a flash of consi able magnitude, whose temperature was sometimes sufficiently hig ignite gas, so that they did not appear to have reached a point of sa even with the use of a high explosive which is said to produce no fl His (Mr. Deacon's) experience in the use of high explosives was tha flame was generally emitted from some, if not all of them.

Prof. Lewes had said that the abolition of the use of blasting-pov would do away with three-fourths of the deaths annually reporte being caused by explosives. This, he (Mr. Deacon) presumed, was sin an estimate which Prof. Lewes had formed; but admitting, for the sak argument, that it was correct, it would be interesting to know what saving in the death-rate would be in those districts where fire-damp inflammable coal-dust did not exist to any great extent. Take, for insta the Midland inspection district. The average number of deaths f explosions of fire-damp amounted, during the 10 years from 188 1894, to 0·5 of a man per annum, or about 0·8 per cent. of the t deaths annually. On the basis of Prof. Lewes' estimate, the death this district per annum from this cause would, therefore, be reduced f 0·5 of a man to 0·12 of a man per annum.

Whilst admitting the responsibility, both moral and legal, of employer to limit the loss of life of his workmen to the lowest practic point, the question is whether it is not going a little too far to set u theory as to the saving which might occur from the use of high plosives as against blasting-powder, to the serious detriment of interests of so important an industry as that of coal-mining. might almost be argued on the same lines, and perhaps with gre force, that the use of railway-trains and sailing-ships should be aboli because the death-rate amongst railway-servants and sailors was so gr the death-rate for 1894 in the case of the former being 1·3 per 1, and the latter 7·7 per 1,000, as against 0·9 per 1,000 coal-mi employed. The ready reply to this would be that such interference v commercial enterprise would not be justified by the saving of life wh

would accrue. Might it not be argued with greater force that the economical production of coal should not be interfered with, under such conditions as those previously referred to, for the sake of such an infinitesimal saving of risk? The abolition of powder for blasting coal would undoubtedly seriously affect its economical production in many mines, more especially those seams which are of a tender nature, and which, owing to the tendency to stick to the roof, cannot be got down economically without blasting. The use of high explosives in such seams produces a much larger percentage of slack than blasting-powder, and in these days of low prices and high wages, such an increase in slack-coal would in many cases result in collieries being closed. The next question to consider was, what would become of the men so deprived of their natural means of existence?

He (Mr. Deacon) said that in some experiments made by him some time ago with roburite as against blasting-powder, in order to test the effect of the former upon the coal, the results were, in a soft coal-seam, an increase of 5½ per cent. of slack-coal, in addition to which the coal was in all cases shattered to a greater extent than with powder, and in a hard coal-seam an increase of about 4 per cent. with similar results as to shattering. The conditions in each case, as to the texture of the seam, the position of the shot, and the depth of holing, were exactly the same.

Until some explosive was discovered which would treat the coal as tenderly as blasting-powder, there seemed to be no reason to justify its prohibition in mines where fire-damp is seldom seen, or where it is only detected in small quantities, and where the coal-dust in the faces is not of a highly inflammable character. At present, so far as he was aware, no such explosive existed, though perhaps ardeer powder (which was not mentioned by Prof. Lewes in his paper) was the nearest approach to such an explosive. It would be interesting to hear from Prof. Lewes how ardeer powder compared with the other explosives mentioned by him in his paper, and perhaps he would deal with this in his reply. It appeared to him (Mr. Deacon) that until some safe high explosive, which was absolutely flameless and could be ignited without a flash from a detonator, was discovered, blasting-powder would continue to be used in those mines where the risks were infinitesimal, unless a large number of collieries were to be closed, and the interests of certain mining districts seriously damaged.

Mr. A. C. Kayll (Newcastle-upon-Tyne) said that he was very much interested in Prof. Lewes' paper, and thought that the tables of gaseous products of combustion would be most valuable for reference by those

who were interested in the subject of explosives. The sensitiveness to ignition of coal-gas mixtures compared with mixtures of pit-gas was very evident from the experiments made by the North of England Institute of Mining and Mechanical Engineers, in which all the safety-explosives fired coal-gas mixtures, both with the stemmed and unstemmed shots; but in pit-gas none of them fired the mixture when stemmed, and only four of the explosives out of the seven fired the gas when unstemmed.

It is stated by Prof. Lewes that in the decomposition of methane a dual action occurred, requiring an appreciable time, whose retarding influence on the chemical changes before ignition took place Prof. Lewes gave as the reason why fire-damp was not so readily ignited by explosives; but when inflammable gases, other than methane, are introduced, no time is given for the products of combustion to sufficiently cool themselves, and the mixture is detonated.

He (Mr. Kayll) gathered from these remarks that when gaseous mixtures are ignited by explosives there ought to be, in the case of mixtures of fire-damp, an appreciable interval of time between the detonation of the shot and the ignition of the fire-damp mixture; but when a coal-gas mixture is employed there would be no such interval, the coal-gas would be ignited immediately on the detonation of the shot.

Some of the experiments made by the Explosives Committee of the North of England Institute of Mining and Mechanical Engineers did not confirm this statement, for in their report there are seven instances of delayed ignitions of gaseous mixtures; six of these were coal-gas mixtures, and only one was a pit-gas mixture. Of the six cases bellite gave one, ammonite gave two, roburite gave one, and carbonite gave two. The shots in each instance were stemmed. The question arises: why should there be retarded ignitions of coal-gas mixtures when, as Prof. Lewes says, no dual action takes place in the decomposition of coal-gas, and therefore there should be no retarding action?

In the *Report* of the Committee of the North of England Institute of Mining and Mechanical Engineers the works of several authors were quoted as explaining that "mere momentary contact of a highly heated body is not sufficient to cause an ignition of an explosive mixture which would be readily ignited by the same body at a lower temperature if left longer in contact with it."

Now, this might afford a satisfactory explanation of the delay in the ignitions of the coal-gas mixtures mentioned above, if it be assumed that there were combustible products or burning solids from the explosives when detonated, but Prof. Lewes tells us that bellite, ammonite, and

roburite yield no combustible products nor burning solids; yet these explosives gave rise to four out of the seven delayed ignitions of the gas mixture cited in the *Report*.

Prof. Lewes had pointed out "chemically" what explosives should do; but, unfortunately, in practice explosives have a way of not doing what they should do, in spite of chemical deductions. The subject still appears to be in its infancy, and he was of opinion that combustion and detonation must be further elucidated before we can explain what now appear as phenomenal results when compared with chemical deduction.

DISCUSSION UPON MR. A. R. SAWYER'S "REMARKS ON THE BANKET FORMATION AT JOHANNESBURG, TRANSVAAL."*

Mr. A. R. SAWYER wrote that the term "basin"† would appear to limit the extent of the Witwatersrand formation unduly, making it seem as if the reefs were contained within a circumscribed area, whereas they extend over a considerable and formerly little dreamed of area. At Johannesburg, the formation occurs as a long synclinal extending far east and west.

The following paper by Mr. Winkhaus on "The Blasting Efficiency of Explosives" was taken as read :—

* *Trans. Fed. Inst.*, vol. ix., page 360. † *Ibid.*, page 361, line 32.

THE BLASTING EFFICIENCY OF EXPLOSIVES.*

By BERGASSESSOR WINKHAUS.

In conducting researches with the object of determining the explosive efficiency of blasting materials, the only possible course is to compare the efficiency of every explosive with that of each of the others and with that of an explosive whose efficiency is already a matter of common knowledge. The best available method for such researches is that of the Trauzl leaden block which was used in the experiments about to be described. Within leaden cylinders, which enclose a cylindrical hollow space, a definite quantity of the explosive under investigation is made to explode, and the resulting expansion of the hollow space is a measure of the detonating force of the explosive.

The leaden cylinders used in the experiments were constructed as shown in Fig. 1 (Plate VII.). They are 9·45 inches (240 millimetres) high, with a diameter of 5·51 inches (140 millimetres). A slightly conical form was selected so as to facilitate the casting of the cylinders. The cylindrical hollow bore is 0·98 inch (25 millimetres) in diameter, is 5·71 inches (145 millimetres) deep, and widens out at its upper end to 2·36 inches (60 millimetres), so that the lid may be properly fitted to it. The best refined soft lead is used for making these cylinders, and with the view of securing the greatest possible uniformity in the substance and make of the cylinders all those made use of in the experiments were cast at the same time.†

The particular explosive under investigation, wrapped in a paper covering, was laid down with the detonator at the bottom of the cylindrical space. The cylinder was then filled up to the mouth with dry sand which had been carefully passed through a sieve, and the whole was closed

* Translated by L. L. Belinfante, B.Sc.

† *Hand-book on Blasting*, by Mr. O. Guttman, page 92 *et seq.* "Ueber die mechanische Arbeit der Sprengstoffe" (The Mechanical Work of Explosives), by Prof. Franz von Rziha, *Dingler's Polytechnisches Journal*, 1886, vol. cclxii., page 128 *et seq.* The leaden cylinders were modelled on those described by Dr. Klose in his paper "Untersuchung von Sprengmaterialien für Bergbauzwecke" (Investigation of Blasting-materials for Mining Purposes), *Zeitschrift für Berg- Hütten-und Salinen-Wesen*, 1896, vol. xxxi., page 91 *et seq.*

by a steel plate, above a sheet of asbestos. The wires of the electric detonators pass through holes bored in the middle of the steel plate and the asbestos sheet (Fig. 1).

The leaden cylinder thus charged was firmly wedged into a stout wrought-iron frame with the aid of an iron plate and two wedges, and the explosive was then detonated (Figs. 2 and 3, Plate VII.). Before and after the firing of the shot, the area of the cylindrical space was measured by means of water poured into graduated measures. The difference of the measurements showed how much expansion had been produced by the explosive.

In order to carry out the experiments under absolutely identical conditions, all explosives were detonated by No. 8 detonators, containing 30·86 grains (2 grammes) of fulminate of mercury. All the safety explosives in use in the collieries of the Westphalian mining district were included in the series of experiments, together with gelatine-dynamit, the last-named being used with the view of establishing comparisons with the efficiency of an universally known explosive. The results of these experiments, which were throughout made with charges of 0·35 ounce (10 grammes), are detailed in Table I. of the Appendix.

On examining the results obtained, one is first of all struck by the fact that, with equal charges of gelatine-dynamit and wetter-dynamit under the same conditions, the figures differ very slightly—at most by 1 per cent. from the calculated average. Just the opposite is the case with the other explosives, which show divergences as high as 11·6 per cent. Results so widely different can be ascribed only to the nature of the explosive itself. This in gelatine-dynamit and wetter-dynamit seems to be very constant, while in the other explosives it is much more subject to variation. For instance, a careful analysis of kohlen-carbonit revealed the presence of a larger proportion of nitro-glycerine in the centre than in the outer layer or covering. According as more of the inner or more of the outer portion was used, greater or lesser expansion of the cylindrical area was observed. When one recollects also the granular condition of the nitrate-of-ammonium explosives, it will be seen that the unequal granulation of the substance must have some influence on the results.*

If the averages be compared one with the other, and the average volume of 640 cubic centimetres obtained with gelatine-dynamit be considered as unity, then the following comparative figures will be got for the various explosives:—

* Dr. Klose, *op cit.* page 96.

1.	Gelatine-dynamit	1·000
2.	Kohlen-carbonit	0·360
3.	Wetter-dynamit	0·508
4.	Progressit	0·620
5.	Westfalit	0·734
6.	Dahmenit	0·773
7.	Dahmenit A	0·784
8.	Roburit	0·858

One may now enquire in what way conclusions can be drawn from the figures thus obtained as to the use and efficiency of the various explosives in practical mining work.

In order to represent graphically the kind of effect which they have, the writer has shown in Fig. 4 (Plate VII.) a general outline (section through the longer axis of the leaden cylinder) of the expansion of the hollow space produced by the explosives: gelatine-dynamit, westfalit, wetter-dynamit, and kohlen-carbonit. Very similar shapes are obtained with roburit, dahmenit, and progressit; but they have been left out of the figure so as to avoid confusion. In all of the expansion-outlines, one notes the more or less round-bellied flask shape of the hollow space which in such experiments is produced by all strongly shattering explosives, and is widely different from the expansion produced by a slowly-acting explosive such as blasting-powder. The shape originated by the last-named explosive with a charge of 0·88 ounce (25 grammes), that is, 2½ times as much as the charge used of the other explosives, is shown in Fig. 5 (Plate VII.). It amounts to 65 cubic centimetres, whence one concludes that the explosive effect of blasting-powder as compared with that of gelatine-dynamit is as 1 : 19, a proportion which does not in the least agree with the figures obtained in practice. Consequently, we may regard a comparison of the explosive efficiency of explosives of widely different rapidities of combustion by the leaden-cylinder test as being valueless.* Moreover, even with high explosives the results obtained are affected by very various circumstances.

In the first place, the resistance of the walls of the leaden cylinder is one factor in the problem. As may be deduced from the sections drawn in Fig. 4 (Plate VII.), the strength of the cylinder walls, and consequently their power of resistance, diminishes as the expansion increases. Therefore a great expansion can be produced by a proportionately smaller force than a lesser expansion.† This assumption was confirmed by the following experiment:—0·35 ounce (10 grammes) of gelatine-dynamit yielded

* Dr. Klose, *loc. cit.*

† To put it another way—as the expansion increases the force necessary to produce it increases in a diminishing ratio.—Translator.

an average expansion of 640 cubic centimetres, but 0·53 ounce (15 grammes) an expansion of 1,054 cubic centimetres; whereas the calculated expansion with the second charge should only have been 960 cubic centimetres.*

This circumstance must, of course, tell very unfavourably in the case of those explosives which produce only slight expansions, and in order to obtain comparable results it is more correct to determine what quantity of each explosive is required to produce a given expansion of the cylindrical space. The explosive effect is then inversely as the quantity of explosive used.

We have endeavoured to determine these weights or charges,† and the experiments are shown in Table II. of the Appendix.

From these experiments, the following comparative figures are deduced for the various explosives:—

Name of Explosive.	Quantities of Explosive necessary to produce a given Expansion. Grammes.	Explosive effect in comparison with Gelatine-dynamit.
Gelatine-dynamit	10 ...	1·000
Kohlen-carbonit	21·5 ...	0·465
Wetter-dynamit	17 ...	0·588
Progressit	17 ...	0·588
Westfalit	14 ...	0·714
Dahmenit A	13 ...	0·770
Roburit	12 ...	0·833

We see, then, that the relations for kohlen-carbonit and wetter-dynamit come out far more favourably than in the previous experiments. The less favourable results shown by progressit are attributable to the fact that the explosive used in the experiments was taken from another case than that from which the sample used in the first series had been taken,‡ and, as experiment No. 3 shows, it was a feebler explosive. The results obtained with the remaining explosives differ very slightly from those previously obtained. The reason why these should have failed to yield more favourable results may be partly ascribed to the smaller difference in expansion of the hollow space, and partly to the irregular, unequal composition of the explosives themselves (a point on which stress has already been laid).

* The expansion produced by the detonators alone may be left out of account in these comparisons, because it only amounted to 9 cubic centimetres according to experiments.

† "Sicherheitssprengstoffe" (Safety-explosives), *Oesterreiche Zeitschrift für Berg-und-Hütten Wesen*, 1894, page 467.

‡ According to the notice on the cartridges, however, the composition was supposed to correspond with that of the first sample.

Whether, however, the figures thus obtained may be directly relied upon in practice is not an easy matter to settle offhand. It would be an interesting and valuable piece of work to determine the value of these results by more searching experiments conducted in the mine. We must call to mind here another essential factor, which intervenes both in the results obtained with the leaden cylinders and in those which we may expect in practice, viz., the varying density of the charges, or the specific gravity of the explosives.

The explosive with a high specific gravity takes up less space than the explosive with a low specific gravity for equal charges. Consequently, in a given length of borehole a heavier weight of the former can be placed than of the latter, and therefore the explosive force concentrated in this length of borehole will be relatively greater in the denser explosive. This is a circumstance which must make itself more particularly felt in practice.

By careful weighing of original cartridges, taking into account their length, diameter, and weight of cover, we have sought to estimate the density of charge of the various explosives in comparison with gelatine-dynamit. We wished, by help of these figures and of the experiments previously tabulated, to calculate what amount of explosive force was developed within a given volume, in comparison with gelatine-dynamit. The results obtained are as follows:—

Name of Explosive.	Weight of equal Volumes in comparison with Gelatine-Dynamit.	Explosive force of equal Volumes in comparison with Gelatine-Dynamit.
Gelatine-dynamit	1·00	1·000
Kohlen-carbonit	0·73	0·339
Wetter-dynamit	0·95	0·559
Progressit	0·60	0·353
Westfalit...	0·55	0·393
Dahmenit A	0·53	0·408
Roburit	0·61	0·509

The figures given in the above table are partly confirmed by the fact that those safety-explosives which yielded the most favourable results, that is, wetter-dynamit and roburit, were packed almost exclusively in cartridges about 1 inch (23 and 25 millimetres) in diameter, while with the others the cartridges were mostly 1¼ to 1½ inches (30 to 40 millimetres) in diameter. They also serve to explain why in stone-work, particularly in cross-cutting, no favourable results have as yet been obtained with safety-explosives. In working coal the attendant circumstances are, of course, different. Here in nearly every case it is found desirable to distribute the effect of the explosive over a great length of borehole.

APPENDIX.

TABLE I.

No. of Experiment	Volume of the Hole in the Leaden Cylinder.		Increase of Volume.	Average Volume.	Difference of Expansion between the Respective Results and the Average Volume.	
	Before Firing the Shot.	After Firing the Shot.				
	Cubic Centimetres.	Cubic Centimetres.	Cubic Centimetres.	Cubic Centimetres.	Cubic Centimetres	Per Cent.
1.—Gelatine-Dynamit.*						
Weight of charge, 0·35 ounce (10 grammes).						
1	62	696	634	640	− 6	0·94
2	62	708	646		+ 6	0·94
3	62	704	642		+ 2	0·31
4	62	695	633		− 7	1·09
5	62	703	641		+ 1	0·16
6	62	708	646		+ 6	0·94
2.—Kohlen-Carbonit.†						
Weight of charge, 0·35 ounce (10 grammes).						
1	62	278	212	232	− 20	9·6
2	62	295	233		+ 1	0·4
3	62	301	239		+ 7	3·0
4	62	281	219		− 13	5·6
5	62	321	259		+ 27	11·6
3.—Wetter-Dynamit.‡						
Weight of charge, 0·35 ounce (10 grammes).						
1	62	384	322	325	− 3	0·92
2	62	389	327		+ 2	0·61
3	62	393	331		+ 6	1·84
4	62	387	325		± 0	0·00
5	62	383	321		− 4	1·22

* According to the analysis made by the director of the laboratory belonging to the Westphalian Miners' Provident Society this consists of :—

	Per Cent.
Blasting gelatine (nitro-glycerine and gun-cotton) ...	64·5
Nitrate of potassium	26·0
Wood-meal	9·5
	100·0

† Containing 25 per cent. of trinitro-glycerine.

‡ The composition is recorded in *Trans. Fed. Inst.*, vol. ix., pages 258 and 259.

TABLE II.

No. of Experiment.	Weight of Charge.		Volume of the Hole in the Leaden Cylinder.		Increase of Volume.	Volume reduced to that with a charge of 10 grammes.
			Before Firing the Shot.	After Firing the Shot.		
	Ounces.	Grammes.	Cubic Centimetres.	Cubic Centimetres.	Cubic Centimetres.	Cubic Centimetres.
1.—Kohlen-Carbonit.						
1	0·71	20·0	62	590	528	264
2	0·86	24·5	62	835	773	322
3	0·79	22·5	62	749	687	305
4	0·76	21·5	62	694	632	294
2.—Wetter-Dynamit.						
1	0·60	17·0	62	695	632	372
3.—Progressit.						
1	0·56	16·0	62	635	573	358
2	0·60	17·0	62	702	640	377
3	0·35	10·0	62	401	339	339
4.—Westfalit.						
1	0·42	12·0	62	594	532	443
2	0·49	14·0	62	700	638	456
5.—Dahmenit A.*						
1	0·47	13·5	62	752	690	511
2	0·44	12·5	62	667	605	484
6.—Roburit.						
1	0·42	12·0	62	710	648	540

* No experiments were made with dahmenit, as it could not be procured. According to these experiments, the charge which would produce an expansion of 640 cubic centimetres may be calculated as about 0·46 ounce (13 grammes).

Mr. E. THOMPSON read the following paper on "The Use of Steel Girders in Mines" :—

TABLE I.—*Continued.*

No. of Experiment.	Volume of the Hole in the Leaden Cylinder.		Increase of Volume.	Average Volume.	Difference of Expansion between the Respective Results and the Average Volume.	
	Before Firing the Shot.	After Firing the Shot.				
	Cubic Centimetres.	Cubic Centimetres.	Cubic Centimetres.	Cubic Centimetres.	Cubic Centimetres.	Per Cent.
4.—Progressit.* Weight of charge, 0·35 ounce (10 grammes).						
1	62	465	403	397	+ 6	1·5
2	62	476	414		+ 17	4·3
3	62	467	405		+ 8	2·1
4	62	429	367		− 30	7·6
5.—Westfalit.† Weight of charge, 0·35 ounce (10 grammes).						
1	62	559	497	470	+ 27	5·7
2	62	533	471		+ 1	0·2
3	62	544	482		+ 12	2·6
4	62	491	429		− 41	8·7
6.—Dahmenit.† Weight of charge, 0·35 ounce (10 grammes).						
1	62	571	509	495	+ 14	2·8
2	62	536	474		− 22	4·5
3	62	557	495		− 10	0·0
4	62	562	500		+ 5	1·0
7.—Dahmenit A.† Weight of charge, 0·35 ounce (10 grammes).						
1	62	551	489	502	− 13	2·6
2	62	550	488		− 14	2·8
3	62	568	506		+ 4	0·8
4	62	588	526		+ 24	4·8
8.—Roburit.† Weight of charge, 0·35 ounce (10 grammes).						
1	62	603	541	549	+ 8	1·4
2	62	609	547		+ 2	0·4
3	62	607	545		− 4	0·7
4	62	625	563		+ 14	2·6

* According to an analysis printed on the cartridge-case, progressit consists of:—

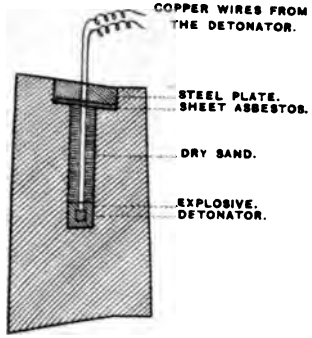
	Per Cent.
Nitrate of ammonium	92·0
Hydrochlorate of aniline	6·0
Sulphate of ammonium	2·0

With this composition (*Trans. Fed. Inst.*, vol. ix., page 266) the safety of this explosive is diminished.

† The composition is recorded in *Trans. Fed. Inst.*, vol. ix., pages 258 and 259.

To illustrate Mr Winkhaus' Paper on "The Blasting Efficiency of Explosives."

FIG. 1.



Scale 8 Inches to Inch

FIG. 3.

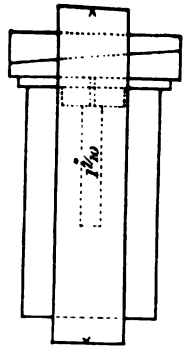


FIG. 2.

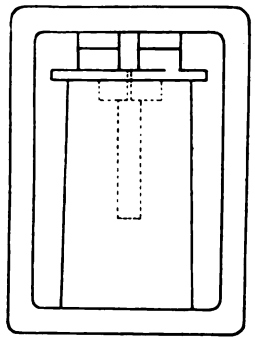
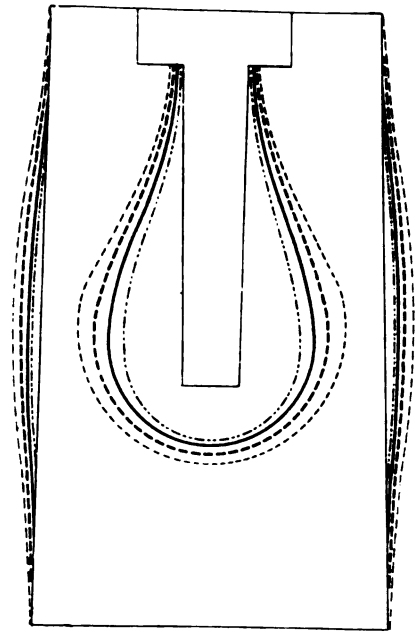


FIG. 4.



ORIGINAL SHAPE.

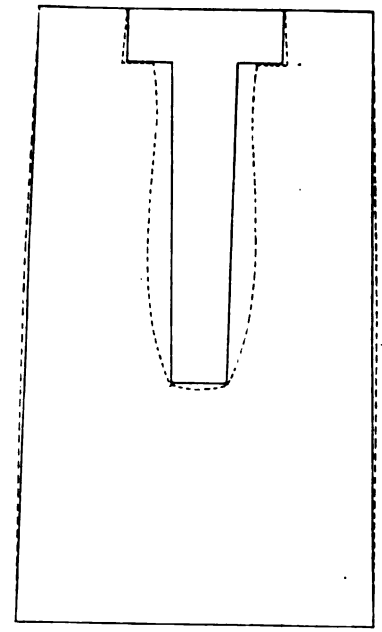
EXPANSION PRODUCED BY A CHARGE OF 10 GRAMMES OF KOHLEN-CARBONIT.

EXPANSION PRODUCED BY A CHARGE OF 10 GRAMMES OF WETTER-DYNAMIT.

EXPANSION PRODUCED BY A CHARGE OF 10 GRAMMES OF WESTFALIT.

EXPANSION PRODUCED BY A CHARGE OF 10 GRAMMES OF GELATINE-DYNAMIT.

FIG. 5.



ORIGINAL SHAPE.

EXPANSION PRODUCED BY A CHARGE OF 25 GRAMMES OF BLASTING-POWDER.

Scale 3 Inches to 1 Inch

[illegible] Institute of Mining & Mechanical Engineers.
Transactions [illegible]

sections may be safely used. In some instances, a 9 feet girder (for an feet span), of the lightest section, is used in the place of larch timbe 9 inches in diameter. In others (taking the same span), a section weigh ing 22 pounds per foot is required in the place of larch 10 inches i diameter. The heaviest section in other cases is used as a substitute f heavier timber. Under comparatively equal loads the various sectio of girders may be used as follow:—

Weight per Foot. Pounds.	Length of Bars. Feet. Feet.
16⅔	6 to 8
22	8 to 10
24	10 to 14

Where weights come on suddenly and with great force, it is safer t use the heaviest section, and in exceptionally heavy parts of a road th girders may be spaced more closely together. In wider spaces, where central support can be used, the strength of a girder is doubled b making use of such supports.

The relative costs are easily ascertained at any time, being depender upon the fluctuations of the steel and timber markets. At the preser time, estimating the girders at £5 per ton, these sections cost respectivel 9d., 1s., and 1s. 1d. per foot.

Comparing these prices with best larch timber, the cost of girders very little in excess of timber, and if the cost of cutting and trimmin the timber be included, with an allowance for waste, steel girders wi probably be found to cost less per foot, and in addition prove muc stronger. Steel girders are also more easily handled, and cost less to s in position.

A larch bar 9 inches in diameter and 9 feet long contains 5 cubic fee and weighs, when dry, 19 lbs. per foot. A larch bar 10 inches i diameter and 9 feet long, contains 6¼ cubic feet, and weighs 24⅛ lbs. pe foot. At 1s. 3d. per cubic foot these bars cost respectively 6s. 3d. an 7s. 9½d. each, while a 9 feet steel girder of light section costs 6s. 9d., an of medium section costs 9s.

A larch bar 10 inches square and 8 feet in span is calculated t break under a load, placed at its centre, of 17 tons.

Girders compare favourably with timber, as they give an addition 4 or 5 inches in the height of a road; they possess greater durabilit where exposed to moist air, which, in some mines, destroys the timber i a few weeks; and they are equally suited for pit-bottoms, main-road and return air-ways.

Girders intended for use in very wet places may be tarred at a slight cost. They can be drawn and reset many times, where perhaps timber would not be worth the cost of recovery. In the event of fire, timber is not only destroyed, but helps to spread its effects, while girders remain intact, and the road in good order. The blocking of the roads caused by floating timber, is also avoided should the mine be flooded with water.

The methods adopted in the setting of steel girders are similar to those employed in setting timber bars. The most general modes are to insert the ends of the girder into holes cut in the sides of the road, or to support them on walls or on wooden props. Where side pressure has to be met, girders resting on wooden props must be wedged at the joint, to prevent the props from being displaced. Another method is to form a shoulder on the girder to form a support for the head of the prop.

It is very important to keep the girders upright; where allowed to cant over their utility is considerably lessened. A ready method for maintaining them upright is to place light timber horizontally from girder to girder, the ends of the timber being held between the flanges of the girders. When canting over they tend to split the wooden props upon which they rest, owing to the edge of the flange of the girder being forced into the timber. To meet these cases a shoe, made of iron or steel, may be placed upon the under flange of the girder. Its under side forms a cap, and fits on the top of the wooden prop. This shoe answers the triple purpose of preventing the canting of girders, the splitting of the wooden props, and their being displaced by lateral pressure, or by collision with tubs.

Girders are also used as props to support the girder-bars, the light section being equal in strength to the timber generally used for that purpose. To secure the girder-props, and so form steel settings, various appliances have been introduced, so that in constructing the settings there is no need for cutting or punching of the girders, which would tend to weaken them.

The first of these appliances is an iron or steel clip, made in two pieces, one half of which fits on either side of the bar and prop when set in the required position, and a bolt passed through the clip securely holds the framework against distortion by any pressure. The ends of the girder being firmly held, it is able to carry nearly double the weight carried by a girder whose ends are loose.

Another appliance is a wrought-iron holdfast or band, made in one piece, and placed obliquely over both the girder and prop when set. An iron bolt is passed through the holdfast at the point where the girder

rests on the prop, and forms a shoulder to prevent its displacement. [redacted] the holdfast passes over the top of the girder it has a greater leverage an[redacted] exerts proportionate power in preventing the canting of the girder.

A third appliance is an iron or steel chair, in which the end of th[redacted] girder and the top of the prop are placed, and are held securely again[redacted] any movement.

Steel settings are also constructed in the form of arches, circle[redacted] rectangles, or squares; they are capable of resisting enormous pressur[redacted] and prove an efficient substitute for brick-arching.

Mr. E. B. WAIN thought that Mr. Thompson had made out a stro[redacted] case in favour of the more general use of steel girders underground. [redacted] believed that they would be more largely used in the future, now th[redacted] girders could be bought at a cost only slightly more than that of go[redacted] larch timber. For use in main roads, where there was no active mo[redacted] ment in the roof or sides, the advantages of steel over timber were evide[redacted] but he must confess that he had some doubt whether it would be advisab[redacted] to use the girders in a newly-packed gate-road, and especially in incli[redacted] seams such as those worked in the North Staffordshire district, whe[redacted] in addition to the sinking of the roof there was also more or less sic[redacted] thrust on the higher side of the level roads. Whatever supports were u[redacted] under such conditions were liable to be disturbed and damaged, for the fo[redacted] was, as Mr. Thompson had remarked, "practically irresistible," and he [redacted] not think it was good policy to place such substantial supports in[redacted] newly-made gob-road. The roof must sink, and although it might [redacted] often necessary to put in some sort of supports they should be, as far [redacted] possible, fixed so that they would not offer such resistance to the sinki[redacted] as would prevent the mass from coming down evenly and regular[redacted] or they would cause fracture. He thought, too, that in many ca[redacted] it would not be good policy to use girders as props in the working-fa[redacted] Unless very great care was taken in setting them with a substant[redacted] wooden lid at each end, there would be great difficulty in cutting the[redacted] out in the wastes. In these two positions, as bars in newly-made pack[redacted] roads, or as props in the working-face, he should hesitate to use gird[redacted] in the place of timber, but for main-roads, he was satisfied that th[redacted] were all the advantages in the use of steel bars which were claimed [redacted] them by the author. Even if the bars could not be reset when damag[redacted] or bent, he thought that their value as scrap steel would more than co[redacted]

the difference in cost between the steel and larch bars. He had recently repaired a road 10 feet wide, which was lined with steel girders weighing 22 lbs. per foot over five years ago. The roof was very wet and the ground was the heaviest he had to deal with, but although the girders had been severely punished and were twisted badly, he found that there was little difficulty and cost in straightening them, and they had been reset in the same length of road. Larch timber 12 inches in diameter in a similar position had been renewed three or four times since the girders were set, so it was not difficult to make comparisons in favour of the steel bars. One of the objections to the use of girders had been that it was sometimes difficult to prevent them from moving and to attach them firmly to the props at the ends, but the appliances which had been described in the paper appeared to meet the difficulty if they did not add unduly to the cost of the setting. He had not found any difficulty from the bars reeling, where care was taken to fix two or three light stretcher-pieces between the bars and where the covering was done properly. In starting a new length of road, it might be found useful to couple the first two or three bars together with light screws or cotter pins passed through holes in the web of the girder, to prevent them from being moved by a sudden blow; but after the first few bars were set there should be no difficulty. If, however, the makers would put on the market girders with broader flanges than those mentioned in the paper, there would be less fear of canting; and there was no doubt that, as there was a greater demand for this class of work, more suitable sections would be rolled. As it was, he could not find, in any dealer's list, girders with flanges equal to the depth, which appeared to be the most suitable section for pit bars.

In conclusion, he should like to put on record some compression tests of props he, with other members, saw made by Prof. Goodman on the occasion of the visit of the Institution to the Yorkshire College last year. They were as follows:—Norway prop, 6 feet long, girth 1 foot 7½ inches, broke under load of 90·8 tons; Norway prop, 7 feet long, girth 1 foot 11 inches, broke under load of 50 tons; steel girder, 6 feet long, 5 inches by 4 inches, 50 lbs. per yard, 5 inches square in section, bent 5¼ inches, under a load of 81·05 tons; steel girder, 6 feet long, 5 inches by 4 inches, 50 lbs. per yard, 5 inches square in section, bent at 96·8 tons, and continued to bend at 140 tons. In each case, care was taken to keep the props exactly vertical, and in the direct line of the pressure. The props were splintered to matchwood at the pressure given above, but the girders showed no sign of fracture.

Mr. J. J. PREST said that the use of steel girders or joists of H section underground in place of timber was a question that had been discussed on more than one occasion in papers brought before the members, but he did not think, generally speaking, that the economy of steel joists, for bars more particularly, in place of timber, had been fully realized by colliery managers, and for that reason he thought Mr. Thompson's paper was particularly opportune at this moment when the coal trade was in so depressed a condition and it was so difficult to find opportunities for reducing the working charges. More especially was this the case in a district like North Staffordshire, where the Coal-measures consisted of an abnormal thickness of soft shales and marls, without any intervening beds of strong sandstones to hold off the superincumbent pressure. Under such conditions, it would be recognized that the cost of timber was an unusually heavy item. During the six months ending June 30th, 1895, he found that the consumption of steel joists at the collieries belonging to the Shelton Iron, Steel, and Coal Company, Limited, had amounted to over 250 tons, or at the rate of 500 tons per annum, and these had been used for supporting the roof and keeping down the floor in situations where timber or brickwork was of no use whatever. They had used them principally in the Upper and Middle Coal-measures under conditions that had tested in a marked degree their efficiency and economy in moving ground. As Mr. Thompson had pointed out, steel girders, costing £5 per ton, are equivalent to larch at 1s. 6d. per foot, the breaking-strain of the former being practically twice as great as the latter; but when the cost of renewing larch, both for material and labour, was taken into consideration, the balance was greatly in favour of steel under any circumstance, but more particularly was this so in the case of haulage-roads and return air-courses that were perpetually on the move. So far his practice had been to line all haulage-roads and return air-courses with steel bars, as circumstances required. They had not been used at the face for a variety of reasons, their use having been limited to permanent roads.

Mr. J. H. MERIVALE said that he was quite in accord with what had been said by previous speakers, but did not quite agree with them as to the first cost. He thought that the cost of steel as compared with the timber used in the North of England was much heavier. Why should they use larch at 1s. 6d. when they could get Norway timber for 6d. or 7d.? The great advantage of steel did not lie in the fact that the cost in the first instance was not very high, but in the durability. On this point of durability he thought that they required further information.

Mr. H. RICHARDSON HEWITT (Derby) wrote that the advantages of steel compared with timber for supporting the roadways of mines could not be over-estimated, and especially at the present time when the price of steel was very moderate compared with what it was in former years. He was inclined to doubt the author's statement that fastening the ends of the girder practically doubled its strength. It did no doubt strengthen the body of the girder, but he would like to know if the author had made experiments which proved this statement. As the weight carried by girders placed on the roadways of a mine cannot be calculated, it would be preferable to use girders sufficiently strong, as proved by experience upon the road on which it is used. The weight used at many collieries is 17 lbs. per foot, but of course the weight must vary at certain places according to practical results. This, however, is found to be a very useful section, and it is desirable to have the girders curved about 3 inches in the centre, as it enables them to better withstand lateral and vertical pressures. One very important item has been overlooked by the author, namely, that girders last three or four times as long as timber bars, and supposing that steel girders cost twice as much as timber bars, there is the saving of labour in re-setting three times, which in a large mine is a very considerable item. It is advisable not to set a girder directly upon a timber prop, but to place a wooden shoe between, with the grain of the shoe at right angles to the working position of the bar.

The CHAIRMAN moved that a vote of thanks be accorded to Mr. Thompson for his paper.

Mr. A. H. STOKES seconded the motion, which was agreed to.

DISCUSSION ON DR. CLOWES' PAPER ON "THE CHANGE OF COMPOSITION PRODUCED IN AIR BY FLAMES AND BY RESPIRATION."*

Mr. A. H. STOKES said that there was one sentence in Prof. Clowes' paper which he trusted would be taken with caution by those who read it. It was this—"The extinction of the flame of a candle or of a safety-lamp in air does not prove such air to be unfit for respiration." He (Mr. Stokes) thought himself that, wherever the flame of a candle would not

* *Trans. Fed. Inst.*, vol. ix., page 376.

burn owing to noxious gases, such atmosphere should be considered un for respiration. Probably Prof. Clowes did not mean it in the way tha he (Mr. Stokes) had taken it, as unfit for respiration, but that it wa not absolutely dangerous to life. He had recently had to investigate the case of two men who lost their lives in an atmosphere in which a candle would not burn.

Mr. J. H. MERIVALE agreed with the last speaker that attention should be drawn to that paragraph, but they must not forget that the tests with the candle were for two purposes:—(*a*) To warn the miner when it was no longer safe for him to remain in his working-place, and for this purpose the candle or safety-lamp was excellent, because it gave warning in good time; (*b*) to let the miner know if he could venture in to save the life of another. Prof. Clowes had shown that, though the candle was extinguished, the atmosphere might be respirable; and what they required, therefore, for this second purpose was a more delicate test. He thought that the gas-flame was a flame which might be used. If the gas-flame went out men could not live; and if the gas-flame would burn men could live. Probably that was what Prof. Clowes had in mind when he wrote the paragraph referred to by Mr. Stokes.

Prof. CLOWES, in reply, said it was quite wrong to state that if a candle-flame would not burn one must not go into such an atmosphere. He based that statement upon his own experiments. Dr. Haldane had breathed air, in which a candle had been extinguished, without inconvenience or without any harm whatever. He should hesitate to go and preach to working colliers that they should be careless; but he did not think he need hesitate to bring a statement of that kind before a scientific society.

The PRESIDENT said Prof. Clowes had given them scientific advice, and it was useful to know that it was possible to breathe where a candle-flame would not burn.

The following paper by Mr. F. H. Mason on "Gold-mining in Nova Scotia" was taken as read:—

GOLD-MINING IN NOVA SCOTIA.

By F. H. MASON.

Twenty-five years ago Prof. Henry Youle Hind read a paper before the Society of Arts on "Gold-mining in Nova Scotia," and the writer proposes to draw some comparisons between the costs and methods of mining then and at the present day. The writer cannot give a better description of the lodes than Prof. Hind, who has made a life-long study of them, and wrote as follows:—

The lodes of Nova Scotia may be grouped as follows:—

I. *Bedded Lodes*, consisting of beds of quartz interstratified with slates and quartzites of contemporaneous age with them: these are the most abundant, and from them a considerable proportion of the gold is obtained.

II. *Intercalated Lodes.*—These almost always, as far as known, occur in slates, and are numerous in broad bands of slate from 10 to 70 feet in width. Where these lodes abound it would be profitable to crush both the slate and the quartz, for gold is not infrequently found in the slate. The best illustrations of the intercalated lodes occur at Sherbrook and Wine Harbour.

III. *Gash Lodes*, occurring where the strata have been locally squeezed out of place. Instances are known in various districts, the most important being at Renfrew.

IV. *True Lodes or Veins*, cutting the strata. Some of these are very rich, but those which have been worked proved very narrow. The irregularity of true lodes is well known, and the fact that hitherto this class has yielded comparatively inconsiderable results should not discourage operations, for true lodes frequently thin out to a mere film of quartz and increase to a thickness of several feet within a vertical distance of a few fathoms.

These lodes occur in the Lower Silurian formations.

Prof. Hind described the Sherbrook gold district as follows:—

If a slightly undulating line be drawn on the course of S. 83 degs. W. (true) or N. 75 degs. W. magnetic north, from area 775, on the east side of the St. Mary's river, it will represent part of the axis of the Sherbrook anticlinal. On the north side of the axis the lodes dip to the north at an angle of about 45 degs., except on approaching the axis, when they commence to curve. On the south side the dip varies from 80 degs. to vertical, except when making the curve. Proceeding south from the axis, the lodes become more persistently vertical, until they acquire a slight northerly dip, thus showing that the form of the anticlinal is that of a slight overturn to the south, as represented in the sections. On making the curve some of the lodes sweep gradually round, with a dip varying from 80 degs. south to 60 degs. south-west, 35 degs. south-west to west 26 degs. west, then gradually increasing until they acquire the normal dip on the north side of the anticlinal of 45 degs. north. The strata and contemporaneous lodes at Sherbrook may be described as beds of

slate and quartzite with thin sheets of auriferous quartz folded in an overturn anticlinal form, and subsequently tilted to the east by a cross anticlinal. The denuded crest of the intersections of the anticlinals has exposed the sheets of quartz in the form of long semi-ellipses. whose bases rest upon Cambrian gneiss, from which the Silurian quartzites and slates have been removed by denudation. Numerous dislocations, having generally a north-and-south course, occur in Sherbrook. These appear to have taken place during the north-and-south folding. Some of them are represented in the plans and in the sections.

Having given a description of a typical gold district, and one from which over 2,000,000 dollars worth of gold has been extracted, the writer will now turn to the methods of mining.

During the 25 years which have elapsed since Prof. Hind read his paper, the mining of gold in Nova Scotia has not progressed by the leaps and bounds which he had hoped to see. The principal improvements have been in the stamp-battery, the fast drop (90 to 100 per minute), taking the place of the slow drop of about 40 per minute, heavier stamps have been introduced and the construction of the mortar improved. Silver-plated copper-plates are taking the place of copper-plates, the length of them being considerably increased, and mercury traps have been generally introduced. Some few mines have put in concentrating machinery, but in the majority of cases the concentrates are allowed to flow away with the tailings, and enormous quantities of gold are being lost yearly through this neglect. This neglect is the more astonishing because in the majority of cases the owners and managers know the value of the tailings which are being lost. The writer has in several instances made assays of concentrates which have run over 10 ounces of gold per ton of concentrates, while the concentrates vary from 1½ to 10 per cent. of the total amount of ore treated. It is unusual for the writer to receive samples of concentrates which run under ½ ounce, although in some few cases they will run only 3 or 4 dwts. per ton. He has proved by experiments in his laboratory that the concentrates are capable of being economically treated by roasting and chlorination or bromination, and in the majority of cases by cyanide of potassium.

The concentrates from most of the mines are mainly composed of arsenical iron pyrites, those from the Montague and Uniacke mines are rich in copper pyrites, and also contain galena and blende in considerable proportions.

No scientific attempt has ever been made to treat these concentrates. A chlorination-works was started at Waverley, the writer's experience being that the concentrates at Waverley are the poorest of any district in the province. The writer has been unable to obtain any reliable record, but has been told that large quantities of salt were used in the roasting,

hat gold was lost in the process. Anyhow, it resulted in failure and bandoned. An attempt to treat the tailings by cyanide of potassium ied at Brookfield by people without experience of the process, and esulted in failure. At the present time, a chlorination-works is erected near Chester, a district where the concentrates are rich, ıe writer hopes that the attempt may prove successful.

ofessor Hind stated:—"From careful assays of numerous parcels ings as they came from the mill and selected indiscriminately, the ge quantity of gold contained was found to exceed 4 dwts. per ton." rriter's experience of samples of tailings sent to his laboratory gives erage in excess of that amount; but such an average would be ·, because it contains several assays considerably in excess, and in cases containing considerable quantities of auriferous mercury; it ncludes assays of tailings, the ore of which never contained any ciable amount of gold. These two factors make it extremely ılt to strike a fair average.

rof. Hind gives as an instance of the way in which mines were worked ars ago the workings on the Tudor lode at Waverley. "The number ıfts by different companies on these lodes within a mean distance of) feet is 54, having a mean depth of 200 feet. This is equivalent shaft to every superficial area of 47 feet." Mr. John E. Hardman w working this property for the Tudor Gold-mining Company, by ies of levels and cross-cuts from a main shaft, and the writer is)ted to him for the following particulars of working expenses:—

ıe property has been worked for three consecutive years; the yearly average has been from 4 to 5½ dwts. per ton; the average width of the quartz-vein ·en and is 12 inches. The cost of mining the quartz per ton has varied from lollars upwards. The average cost per ton for mining, milling, and incidental ses for last year was 3·20 dollars; this is from a depth exceeding 225 feet, s deep as 400 feet. The costs include pumping, hoisting, and all milling work. ıilling cost and incidentals include salaries and office expenses, but exclude)pment and exploitation.

Many mines in Nova Scotia to-day, are unfortunately not worked the same degree of economy, and the writer regrets that the Tudor is an exceptional case, but it shows what can be done with a proper tific knowledge of methods of mining.

'he gold-miners of Nova Scotia have latterly been turning their tion to the large intercalated belts of lower-grade ore, and in this he future of gold-mining in this province.

.s an instance, the writer may quote the Richardson mine in the nont district, the lode has a minimum width of 6 feet, and a

maximum width of 17 feet, with an average width of about 11 feet. The yield runs from 4 to 8 dwts., with an average yield in excess of 5 dwts. of free milling gold, the concentrates are totally disregarded, as at many other mines. This lode has been milled and mined for 2·27 dollars per ton, including costs of pumping, management, and office expenses, no allowance being made for wear-and-tear of machinery.

The majority of paying mines to-day are old workings which the old miners (most of whom were brought up as "tinkers, tailors, soldiers, sailors, apothecaries, or ploughboys") through lack of knowledge considered exhausted.

A typical instance may be quoted in the Hardman & Taylor property at Oldham.

An English company sank £16,000 in this property without returning any dividends. Twelve years ago Mr. Hardman assumed the management, and has taken from it, without expending any large amount of capital, over 500,000 dollars worth of gold, while in some years the profits exceeded 40,000 dollars. Through Mr. Hardman's kindness the writer is able to give the following particulars:—

The Dunbrack vein has been the chief producing vein during the past ten years, over 400,000 dollars having been obtained during that time from 7,600 tons of quartz. Several phenomenal yields have been recorded from this vein, such as in August, 1885, when 125 ozs. were returned from 2·40 tons, and in 1890 when 37 tons yielded 1,037 ozs., and in the same year 12 tons yielded 530 ozs. In 1891, 48 tons yielded 757½ ozs., and in the same year 88½ tons gave 1,084 ozs. In August, 1893, 2 tons gave 250 ozs., or at the rate of 125 ozs. per ton. This year was the largest in the history of the district, the gross yield being 62,000 dollars. The Dunbrack vein has been opened by five shafts or inclines, varying from 157 to 483 feet in depth, and by levels at 150, 250, 300, and 450 feet; from the 450 feet level a winze was sunk 124 feet, making the greatest depth on the incline 574 feet, equivalent to about 407 feet of vertical depth.

The workings are intersected by several small slides or faults, from a few inches to 6 or 7 feet in width, and are cut by two main dislocations, one of about 112 feet, which has been cut through in each level. The other large fault is supposed to be about 125 feet in extent, but no workings have as yet been carried beyond that fault.

The concentrates from this mine have been collected, and average from 65 to 70 dollars per ton.

Other instances of old mines being successfully reopened may be cited, such as the Antigonish Company's mine at County Harbour, the Pictou Development Company's property at Renfrew, and the Golden Lode Mining Company's mine at Uniacke. Mr. A. A. Hayward has given the writer the following account of the latter mine:—

During the last three years 200,000 dollars worth of gold has been extracted, the average yield being over 10 ozs. per ton, the vein is 8 inches wide, and dips

32 degs. The maximum depth we have reached is a little over 500 feet, on the incline where the quartz is as good as ever. The capital of the company is 30,000 dollars, and dividends are being paid at the rate of 5 per cent. per month, or 60 per cent. per year.

Amongst other improvements in the methods of mining is the use of machine drills, worked at pressures of from 60 to 100 pounds per square inch. A low-grade dynamite (about 40 per cent. of nitro-glycerine) has almost universally superseded blasting-powder; no attempts have been made to use the higher grades of dynamite, gelatine-dynamite, or blasting-gelatine. Dynamite has been considerably handicapped, as there is a heavy provincial import duty on it, and miners are unable to get it from the upper provinces, where it is manufactured, on account of the Government prohibiting its transit over the Inter-colonial railway. However, through an agitation last year amongst mine-owners the local manufacturers have considerably reduced their prices, and a 40 per cent. dynamite can now be obtained at 16 cents per pound.

Perhaps one of the most notable features in the gold-mines of Nova Scotia is the lack of tramways from the pit-heads to the stamp-mill, the ore in many cases being hauled long distances by carts; this is due to the want of sufficient initial capital. Indeed, the want of capital is seen right through the gold-fields; it prevents the proper exploiting and development of the mines, and consequently when a difficulty is met with, such as a fault cutting off the vein, a good mine is often closed. The mines are not opened sufficiently, nearly all the profits going to dividend account, instead of some being reserved for development.

In attempting to interest capital in Nova Scotian gold-mines, one is often met with the statement, "The veins in Nova Scotia are narrow, and the quartz is expensive to extract." The writer wishes to distinctly place on record that the first part of this statement is only partly true, and that the latter part is wholly untrue. Anyone starting mining operations in Nova Scotia may have the choice of narrow rich veins, varying from a ½ inch to 18 inches in thickness, and carrying sometimes over 100 ounces per ton, or they may content themselves by working the big low-grade belts, from 10 to 70 feet wide, carrying from 2 to 8 dwts. of free-milling gold, and often as much as 5 dwts. in arsenical iron pyrites besides. Such belts occur in the Goldenville and Wine Harbour districts, and offer legitimate investment for capital. The second part of the statement is best refuted by Mr. Hardman's experience in working a 12 inches vein for 1·25 dollars per ton at the Waverley mine.

Labour in Nova Scotia is cheap, good miners commanding fr 1·25 dollars to 1·75 dollars per day, labourers from 1 dollar to 1 dollars, and skilled mechanics from 1·75 dollars to 2·50 dollars per d Coal may be obtained from 2·50 dollars to 3 dollars per ton at the p head, and wood can generally be had for 2 dollars per cord at the mi stores, explosives, etc., are also moderate. Nearly all classes of mini and milling machinery are made in the province, and are equal to a thing that can be imported, and mining machinery not made in t province may be imported free of duty. Most of the gold-mines within twelve days from London and four days from New York, wh many may be reached in two days less. Many of the mines have valua water-privileges. The winters, though long and severe, never interf with mining operations, other than surface-prospecting. The climate healthy, and sport with both gun and rod is good.

The writer is satisfied that the gold-mines of Nova Scotia offer legitimate source of investment for capital, and with proper a economical management, remunerative returns may be looked fo Prof. Hind gave nine reasons why failure and collapse in place of co tinued prosperity have characterized some mining properties in Nov Scotia, and they are as true to-day as they were twenty-five years ago. These reasons were:—

1. The absorption of all returns to pay large dividends.
2. The small size of some of the properties.
3. Insufficient working capital at the outset.
4. An uniform neglect in preserving records and plans in detail of workings.
5. Inadequate machinery and appliances to save gold.
6. The want of labour-saving machinery.
7. Ignorance respecting mining operations, the gold streak or "chimneys," or "pipes," or zone of auriferous quartz.
8. General neglect of contract and tribute work.
9. And as a necessary result of the foregoing, the frequent incompetency of some so-called managers.

As a typical instance of the way in which some mines are mismanaged, on a visit to one mine, which has since collapsed, the writer found six pumps in one shaft and the mine full of water, while a neighbouring mine was being kept free with one pump.

The table on the opposite page gives the returns from the different gold-mining districts for the year ending September 30th, 1894

It would be impossible to close a paper on the gold-mining of Nova Scotia without a reference to the Government Department of Mines. More than half the revenue of the country is derived from its mines, and yet there is much that the country might do for the miner which it leaves undone.

District.	No. of Mines.	Days' Labour.	No. of Mills.	Tons Crushed.	Yield of Gold per Ton.	Total Yield of Gold.
					Dwts. grs.	Ozs. dwts. grs.
Tangiers and Mooseland ...	2	5,118	2	1,469	7 6	464 7 0
Caribou and Moose River ...	4	21,657	3	9,727	5 17	2,779 16 17
Renfrew	1	5,020	1	757	15 14	590 0 0
Sherbrook	3	8,414	2	708	17 0	552 16 12
Fifteen Mile Stream	1	8,354	1	1,171	9 9	552 0 0
Uniacke	3	10,797	2	1,544	18 1	1,394 8 1
Waverley	1	19,397	1	9,310	3 23	1,860 1 0
Whiteburn	1	4,846	1	555	12 3	336 8 0
Malaga	2	3,649	2	1,688	12 13	1,060 11 0
Lake Catcha	2	12,522	3	2,387	14 8	1,715 6 0
Stormont	5	16,768	6	6,628	5 23	1,980 4 18
Salmon River	1	5,496	1	1,467	3 16	271 5 0
Oldham	2	3,623	2	981	11 3	546 17 16
Unproclaimed districts ...	5	13,479	6	939	18 15	876 5 12

(1) There are no plans kept of the workings, consequently when a mine is shut down the plans are often lost, and if at any time anyone desires to reopen it, the task is rendered difficult and dangerous, often all the information obtainable being what can be obtained from old miners. (2) In what is known locally as the Blue Book (which is a yearly record of the mining industry) there is a vast amount of room for improvement. The Blue Book of 1894 is infinitely inferior to that of 1870, it contains many inaccuracies, and instead of being a means of interesting capitalists in the mines of the country, it is calculated to have exactly the reverse effect. (3) Proper surveys and maps should be at once made of all the mining districts, distinctly marking existing and old workings, these would meet with a ready sale amongst mine-owners and mining engineers.

The Government has lately given a grant to the Mining Society of Nova Scotia, which institution is doing much to promote the mining industry.

As a rule if anything is properly laid before the Government, they are willing to move in the matter, and many of these omissions are due to the mine-owners themselves not bringing the matter properly to the notice of the Government.

The following paper by Mr. Wm. Hamilton Merritt on the "Economic Minerals of the Province of Ontario, Canada," was taken

ECONOMIC MINERALS OF THE PROVINCE OF ONTARIO, CANADA.

By WM. HAMILTON MERRITT.

Geography.

The Province of Ontario is the most central province of the Dominion of Canada, unless the much smaller Province of Manitoba, abutting immediately on the west, can more properly claim that position.

Ontario closes around the northern shores of all the great chain of lakes, and stretches east and west (from near the junction of the Ottawa and St. Lawrence rivers to the Lake of the Woods) for a distance of about 1,250 miles.

The great extent of territory covered by this province from east to west will perhaps be more easily recognized when it is stated that it overlaps parts of the States of New York, Pennsylvania, Ohio, Michigan, Wisconsin, and Minnesota of the United States of America, bounding the Province of Ontario on the south.

From the Great Lakes the province stretches, in somewhat a wedge-shape with a broad base, to the shores of James' Bay (the southernmost bay of Hudson's Bay), a distance from Toronto (on Lake Ontario) to the mouth of the Moose river (on James' Bay) of 540 miles, and from the northern shore of Lake Superior to Fort Albany (also on James' Bay) a distance of 350 miles.

The population of the province was placed at 2,114,321 in the census of 1891, chiefly resident in the eastern portion, or the peninsula, of Ontario.

Its total area is 222,000 square miles, including 2,350 square miles of water.

Fig. 1 (Plate VIII.) is a sketch-map of the Province of Ontario, and gives an idea of its situation and area. The approximate general position of the more important economic minerals is indicated on the map.*

* Owing to the small size of the map, some of the mineral deposits have been lettered on the wrong formation, though in the immediate vicinity of where they actually exist.

Geology.

The greater part of Ontario is composed of Archæan rocks, concerning which a vast amount of work yet remains to be done. The more these older rocks are investigated the more clearly is their value recognized as the bearers of useful minerals. Especially is this the case with the Huronian, which occupies great stretches of country, lying to the north of Lakes Huron and Superior and in the Rainy river district. These rocks are similar to the great iron-bearing series of northern Michigan and Minnesota, which, in several places in Ontario (as well as near Ishpeming, Michigan), have also been proved to carry gold-bearing quartz-veins. Overlying the Archæan, the Cambrian, Silurian, and Devonian formations occur most extensively in the peninsula of Ontario, between Lakes Ontario and Erie on the south and Georgian Bay and Lake Huron on the north, and continued on to Great Manitoulin Island to the westward. A considerable area of these post-Archæan formations occurs between the Moose and Albany rivers, to the south of James' Bay, which they fringe. Patches of Cambrian rocks of economic importance occur in the vicinity of Thunder Bay, fringing Lake Nipigon, also on Michipicoten Island, and at Point Mamainse, and a small Cambrian and Silurian area forms the extreme eastern end of the province between the Ottawa and St. Lawrence rivers.

With the exception of recent clays and gravels, no formation of greater age than the Devonian is found in the Province of Ontario.

The writer has endeavoured, by shading the above-mentioned map, to designate the geological systems or epochs, but without colouring it is not possible to conveniently designate the subdivisions or groups, a designation which, however, for the purposes of this paper is not necessary.

The geological divisions of the rocks of Ontario, in descending order, are as follows:—

Systems.	Formations.
Recent	... Soils, peat, shell-marl.
	Lacustrine and fluviatile clays, sands, etc.
Pleistocene ...	... Saugeen clay, Artemesia gravel, Algoma sand.
	Sand, gravel, and shingle of the country north of the Great Lakes.
	Erie clay, calcareous and non-calcareous.
	Clays, north of the Great Lake.
	Boulder-clay, drift, or till.
Devonian ...	... Chemung and Portage.
	Hamilton.
	Corniferous.
	Oriskany.

UPPER SILURIAN ...	Lower Helderberg.
	Onondaga.
	Guelph.
	Niagara.
	Clinton.
	Medina and Oneida.
LOWER SILURIAN ...	Hudson river.
	Utica.
	Trenton.
	Black river and Bird's-eye.
	Chazy.
CAMBRIAN	Calciferous.
	Potsdam.
	Nipigon.
	Animikie.
ARCHÆAN	Huronian.
	Laurentian.

Owing to the absence of fossils considerable difficulty occurs wi reference to the division of the lower series. The Laurentian is various divided into two or three groups, and the Huronian has been divided in two divisions in different fields by some observers; but the work done far in this direction in Ontario is not conclusive.

Considerable uncertainty also exists as to the exact ages of t Animikie and Nipigon rocks.

United States geologists now pretty generally give the name Algonkian to the series of rocks older than the Cambrian, and young than the fundamental complex of non-clastic crystallines for which t term Archæan is still retained. On the south side of Lake Superi according to Messrs Irving and Van Hise, the Algonkian consists of a aggregate thickness of over 60,000 feet of rocks in which three gener subdivisions, separated by great unconformities or time-breaks, ha thus far been recognized. The Keweenawen or copper-bearing seri which consists of sandstones, conglomerates, lavas and tuffs, being t upper, and resting unconformably upon the two great iron-bearing seri of the Upper and Lower Huronian, which include all the economical important iron deposits at present known in the region.

ECONOMIC MINERALS AND THEIR OCCURRENCES.

The mineral production of the province for the year 1894 is given b the Bureau of Mines, as shown in the table on the opposite page.

In speaking of the economic minerals, it might for some reasons ha been preferable to limit the description to only such as are being work at the present time, but the author's object is to point out minerals whi

Product.	Quantity.	Value.	Workmen.	Wages.
		Dols.		Dols.
Dimension-stone ... cubic feet	1,340,000	360,470		
Heads and sills ... „	47,070	15,900	854	336,700
Coursing-stone square yards	22,000	36,000		
Rubble, etc.... cubic yards	223,000	142,000		
Sand and gravel ... „	733,500	203,450	175	61,650
Natural rock-cement barrels	55,323	48,774	63	13,020
Portland cement ... „	30,580	61,060	105	31,858
Lime ... ... bushels	2,150,000	280,000	575	108,000
Drain-tiles ... ... number	25,000,000	280,000	2,375	388,000
Common bricks ... „	131,500,000	690,000		
Pressed bricks, plain „	22,460,000	198,510		
Pressed bricks, fancy „	2,896,000	34,160	209	95,400
Roofing-tiles ... „	100,000	1,200		
Terra-cotta	.....	52,360		
Sewer-pipes	.....	207,000	56	23,000
Pottery	.....	134,000	160	47,000
Gypsum ... tons (2,000 lb.)	3,253	9,760	36	9,500
Calcined plaster, etc. „	1,442	22,697		
Salt ... ... „	35,215	115,551	135	43,350
Nickel ... ... „	2,570½	612,724	655	311,719
Copper ... ... „	2,748	195,750		
Cobalt ... ... „	3½	3,500		
Gold ... ... ounces	2,022½	32,776	92	38,032
Petroleum ... imperial gallons	34,912,360	.....	.....	.....
Illuminating oil ... „	14,349,472	1,337,040		
Lubricating oil ... „	3,817,181	242,688		
All other oils ... „	10,632,141	343,416	486	279,930
Paraffin wax ... ... lbs.	2,754,300	152,467		
Fuel product	.....	71,326		
Natural gas, thousands of cubic feet	1,653,500	204,179	99	53,130
Totals	.....	6,088,758	6,075	1,840,289

occur in workable quantities, geologically speaking, although through a depression of prices, as in the case of silver, or for lack of capital, as in the case of iron, they are not being worked at the present time.

The minerals which are believed to exist in the province in workable quantities will be described shortly, and some of the more important localities where they are found alluded to, with perhaps a typical example or two of the mode of occurrence.

While the writer has not hesitated to draw from the Government reports for information or illustration, most of the descriptive matter and nearly all the illustrations are taken from personal observation for nearly twenty years.

Arsenic.

Arsenic has been produced from mispickel, obtained from arsenical gold-veins, cutting syenite, in Hastings county. At present the industry is quiescent, but it will in all probability be resumed some day, as

several of the veins in the above-mentioned district are heavily charge[illegible] with mispickel, and the average gold content of the veins is said to [illegible] satisfactory. One large works was constructed at which the ore w[illegible] crushed, rolled, concentrated, roasted, and chlorinated. The gold valu[illegible] were not nearly extracted and the tailings were washed with profit. T[illegible] mispickel carries in places about 14 dollars of gold per ton on an averag[illegible] and it has been found containing 6 ounces of gold per ton. The followi[illegible] are some examples of gold contents of arsenical pyrites from the Marmo[illegible] district, Hastings county, collected in about one pound lots by office[illegible] of the Geological Survey and assayed by Dr. Hoffman, chemist of t[illegible] Survey:—Ounces of gold per ton of 2,000 pounds, (*a*) 0·467, (*b*) 0·17[illegible] (*c*) 2·392, (*d*) 1·400, (*e*) 1·633, (*f*) 2·858, (*g*) 0·117, and (*h*) 0·117.

Antimony.

Stibnite has been found near Sault Ste. Marie. The vein is said [illegible] occur in a chloritic schist, and to comprise 18 inches of pretty solid o[illegible] with 4½ feet more of vein-matter containing stibnite, sparsely dissem[illegible] nated through it. Antimony has also been found in Barrie townshi[illegible] and is alluded to further on under the heading of *Silver*.

Building-materials, etc.

Under this heading come a great variety of substances in whic[illegible] Ontario is exceptionally rich, viz., ordinary building-stones, granite[illegible] marbles, sandstones, limestones, natural cement-rock, the ingredien[illegible] for Portland cement, clays suitable for bricks and tiles, and cla[illegible] suitable for use in the manufacture of earthenware, terra-cotta, a[illegible] sewer pipes. Practically speaking, it may be said that there is an u[illegible] limited supply of all the above substances, and that it is merely t[illegible] lack of demand which limits their production to almost any extent.

Granites and marbles are found in many localities, varying [illegible] structure and colour, and in freedom from joints and cracks, whi[illegible] conditions determine their suitability for building or ornament[illegible] purposes.

The demand for ornamental stone is small in the province, and it [illegible] imported to a considerable extent, the expenses of opening up a qua[illegible] and procuring a modern plant for extracting the stone in most cases m[illegible] than off-setting the comparatively small local demand.

The only granite-quarry at present in operation is at Kingston, wh[illegible] a pinkish quartz-syenite is quarried and taken in barges to the mill [illegible] Ottawa, where it is cut and polished. The refuse at the quarry is bro[illegible] up into blocks for pavement. The granites are of Laurentian [illegible] Huronian age, chiefly the former.

The marbles are generally highly crystalline and occur in thick beds in the Upper Laurentian, usually designated "crystalline limestone." Oftentimes they are pure white, and present a beautiful appearance when polished. In other places slabs of salmon-pink colour are obtainable, and again light grey and dark grey (almost black) coloured marbles are quarried, especially for monumental purposes.

This crystalline limestone occurs in enormous beds of 500 and 1,000 feet and upwards in thickness. It resists the weather remarkably well; edifices with this material built into them have shown little effect from the weather after from twenty to forty years' exposure. At Gouverneur, in the State of New York, where a large market is enjoyed, the operations on this marble are enormous. Fig. 2 (Plate VIII.) is an example of one occurrence in Ontario.

The Huronian marbles are not so largely crystalline as the above-mentioned, they are more homogeneous and of the close-grained texture that we are accustomed to see in marble. A great band of this marble, about 250 feet wide, occurs near Sault Ste. Marie, made up of a soft blending of green, pink, and pure white bands. The occurrence of this bed is represented in Fig. 3 (Plate VIII.).

Sandstones for building purposes are obtained chiefly from the Nipigon formation, which yields both red and white sandstones of excellent quality; from the Potsdam, which yields sandstones suitable for glass-making as well as building-stone; from the Medina (Fig. 4, Plate VIII.), which supplies the city of Toronto and vicinity with both white and brownish-pink coloured sandstone (the latter especially being highly esteemed as a building-stone), and from part of which grindstones and scythe-stones are manufactured or can be manufactured.

The sandstones of the Oriskany, at the bottom of the Devonian, are excellent for building purposes, and glass can also be made from them.

Perhaps the formation which yields the best material for glass-making, so far as purity and the absence of any colouring matter is concerned, is the Huronian, in which great thicknesses of pure white quartzite are found.

Sandstones are found in the same formation, though not yet worked, also a handsome jasper-conglomerate and ornamental argillites.

Of other ornamental stones, serpentines have been found, but they are not yet developed to any considerable extent.

Common blue-bedded limestones and dolomites abound, and are especially quarried for building purposes from the Black river and Bird's-eye, the Trenton, the Guelph, and to a less extent from the Onondaga, and the Corniferous formations.

All of the above-mentioned limestones, including the marbles of the Laurentian and Huronian, are burned into excellent lime in different parts of the province.

Lithographic stone is quarried from the Black river and Bird's-eye formation near Marmora. Much of the stone is well adapted for lithographic work, but there are other layers in which the development of small crystals of calcite detracts from its usefulness for this object.

Natural cement-rock is quarried, burnt, and ground from one of the lower beds of the Niagara formation, and also from a layer in the Trenton formation. The cement-rock in the *Eurypterus* beds of the Lower Helderberg, which is developed to a very large extent in the United States, has not yet been operated in Canada. These natural hydraulic cements stand strain-tests of from 100 to 190 pounds to the square inch in 30 days.

Portland cement is also manufactured from calcareous marl and clay in several places, and it is said to compare very favourably with imported Portland cement, tensile tests per square inch of section of 425 pounds being recorded in 6 days and of 660 pounds in 90 days.

Clays for brick or tile-making purposes are common in all parts of the province. The Erie clay burns to white bricks and tiles, while the marine clay to the east burns to a red colour. The decomposed red shales of the Medina formation furnish a red clay, from which terra-cotta work and the best quality of red pressed-bricks are manufactured. Fig. 4 (Plate VIII.) shows the mode of occurrence of this clay. The Medina formation is exposed for a very considerable distance, and the clay-bed sometimes reaches a thickness of 175 feet.

Kaolin is reported to have been found along the Missinaibi and Moose rivers, Algoma district, but it has not yet been developed.

Talc and actonolite are found in a number of places in Eastern Ontario, and are used as a lubricant, for fire-proof roofings or linings, etc.

A somewhat impure asbestos has also been found with serpentine in several places, but as yet workable veins of the fibrous serpentine (chrysotile), which is developed to such a large and profitable extent in the eastern townships in the province of Quebec, has not been found in Ontario.

Gypsum.

This mineral is found in the Onondago or gypsiferous formation of the Upper Silurian. It occurs in beds varying from 3 to 7 feet in thickness in the peninsula of Ontario, along the Grand river.

Dr. Bell reports the occurrence of beds of gypsum on the Moose river, towards James' Bay, of some 10 to 20 feet in thickness.

Along the Grand river, the beds occur in lenticular form, thinning off towards the periphery. There were different conditions during deposition as shown by argillaceous bands having been developed between the bands of gypsum. The following is a section of one of the beds:—

	Thickness.
Erie clay, or cannel clay	15 to 20 feet.
Boulder-clay, or hard pan, with nodules (often vesicular dolomite)	6 inches to 8 feet.
Blue shale	*nil* to 6 inches.
*Part mined**—	
Bluish gypsum, or "top stone" ...	*nil* to 1 foot.
White gypsum	2 to 3 feet.
Hard calcareous band...	"parting" to 2 inches.
White gypsum	1 foot.
Hard calcareous band, or "big band"	4 to 6 inches.
Greyish gypsum, sometimes absent ...	average 1 foot.
Very hard calcareous band, 1 inch to 1 foot, and average 2 to 3 inches.	
Mixed shale and gypsum.	

The white gypsum is chemically pure gypsum, and the bands are a mixture of carbonate of lime and gypsum, with less than 2 per cent. of iron and alumina. Dr. Bell reports that

Two grades of gypsum are found along the Grand river—the white and the grey. The latter occurs in the vicinity of Paris, and both in the beds lower down the river. The grey gypsum is used as a fertilizer, it being unsuitable in colour for alabastine, parian cement, plaster of Paris, or any kind of ornamental work. The white answers for any purpose, but should the demand increase, it will doubtless be used chiefly in the arts hereafter.

The calcined plaster used in Ontario has, up to the present time, been supplied almost wholly from Nova Scotia and New Brunswick; but as an excellent article is now being made on the Grand river, at points convenient for shipment by railway, the manufacturers believe that they soon will be in a position to displace the Maritime provinces' plaster in the Ontario market.

The chemical difference between the white and grey, or pure and impure, is shown by the following analyses of the Ontario gypsums on the Grand River :—

	White.	Grey.
Sulphate of calcium	79·07	54·19
Insoluble matter	0·00	15·60
Iron and alumina	Trace	1·60
Carbonate of calcium	Trace	11·41
Carbonate of magnesium... ...	0·00	3·60
Water and loss	20·93	13·60
Totals ...	100·00	100·00

* The top is sometimes found to be grooved and polished by ice-action.

The mode of preparing stucco or plaster of Paris, as generally adopt both in the United States and Canada, varies somewhat from t methods in vogue in most European countries, where the rock is large calcined before grinding or, where ground previously, is calcined on lo stationary tables or on circular rotary tables. The practice on the Nor American continent is first to crush the rock through a Blake-ty crusher, then to run it either through some form of disintegrator, or, i older style mills, through a cracker of the coffee-mill type, and, finally, th pulverized rock is brought to a flour fineness by the ordinary burrston dressed deeper than is usual in a flour-mill. The fine raw plaster is the run into a kettle of about 9 feet in diameter by about 6 feet high, whic has four cross boiler-iron pipes, 10 inches in diameter, crossing throug the inside. There is a heavy cast-iron ring for the bottom to rest o and the bottom is composed of a heavy convex cast-iron casting. Th top is covered with sheet-iron, and in it is a manhole for feeding in th plaster. In the centre is a wrought-iron shaft, with stirrers, which are ke in motion and prevent the plaster from being unequally calcined. Whe operating, the plaster boils violently inside this large pot and, wit experience, the calciner can tell, by looking in the manhole, just when t stop and leave the desired amount of water in the plaster, theret affecting its setting time. When finished the plaster runs out of a spo into a cooling bin. After calcining, the finest qualities are bolted throug screens of 80, 60, and 40 mesh respectively. A kettle of the size me tioned above will calcine about 12 tons a day.

Salt.

Rock-salt occurs in very thick beds below the gypsum horiz in the Onondaga (salt-rock) formation. It is reached by borings in th western part of the peninsula of Ontario. The beds of salt run uninte ruptedly into the States of Michigan and Ohio. In the borings whi have been made, one or more beds are met with at a depth of abo 1,000 feet from the surface, varying in thickness from 20 to 100 fe The quantity is practically unlimited, and the quality is excellent.

The salt is obtained altogether in solution and then evaporated. Th brine is generally about 100 degs. (one-fifth) salt, the maximum of satur tion.

The overlying beds of gypsiferous rocks cause a certain amount gypsum to be present in the brine, but most of it is got rid of in th process of manufacture.

As an example of a borehole, the following log is given. It w sunk by Mr. Attrill at Goderich:—

	Feet.	Inches.
Clay, gravel, and boulders...	78	9
Dolomite, with thin limestone-layers	278	3
Limestone, with coral, chert, and beds of dolomite	276	0
Dolomite, with seams of gypsum...	243	0
Variegated marls, with beds of dolomite ...	121	0
Rock-salt, first bed	30	11
Dolomite, with marls towards the base	32	1
Rock-salt, second bed	25	4
Dolomite	6	10
Rock-salt, third bed	34	10
Marls, with dolomite and anhydrite	30	7
Rock-salt, fourth bed	15	5
Dolomite and anhydrite	7	0
Rock-salt, fifth bed	13	6
Soft marls, with anhydrite	135	6
Rock-salt, sixth bed	6	0
Soft marls, with dolomite and anhydrite ...	132	0
Total depth bored ...	1,467	0

The following analysis of brine made by Dr. Sterry Hunt is a fair indication of its average quality:—

	Grains per Gallon.
Chloride of sodium	236·410
Chloride of calcium	0·190
Chloride of magnesium	0·410
Sulphate of calcium	4·858
Total	241·868
Specific gravity	1·187
Degrees of the salometer	92

The ordinary mode of raising the brine is by a pump making about 30 strokes a minute, lifting about 18,000 gallons per day of 10 hours. The brine is pumped into large vats or tanks, whence it can be directed at will into the evaporating-pans. The size of the ordinary pan is about 100 feet long by 26 feet wide, and it produces about 100 barrels of salt a day (280 lbs. to the barrel). The evaporation is produced by means of a fire placed underneath the pans.

The manufacture of salt is most largely developed in the counties of Huron, Bruce, and Lambton.

Nickel.

Nickel ore is worked only in one section of the country, about Sudbury, lying partly in the Nipissing and the Algoma districts. It occurs as nickeliferous pyrrhotite in greenstone of Huronian age. A greater or lesser quantity of copper pyrites is associated with the

pyrrhotite in the different ore-bodies, varying from 7 to 0·75 per cent. or less of copper. The nickel content of the pyrrhotite averages from 1·5 to 3 per cent., but in some ore-bodies 30 per cent. of nickel ore (pentlandite) has been mined, and ore running about 10 per cent. of nickel has been shipped. Sometimes the pyrrhotite is found to carry little or no nickel. The remaining contents (besides nickel and copper) of the average ore runs about 63 per cent. of pyrrhotite and 30 per cent. of rock. Of nickel minerals, pentlandite, gersdorffite and niccolite are found.

The ore occurs irregularly in large lenses, dipping (south-east) and striking (north-east) with the formation. The ore is also found disseminated through the greenstone with which it has undoubtedly been brought up. The greenstone hills can be traced for long distances through the country, and the ore-deposits, occurring at uncertain intervals, are distinguished by the red colour given to the soil by the decomposed ferruginous matter or gossan. The ore is hard, and the ore-lenses as a rule form hills or mounds.

While differentiation explains the formation of perhaps most of the ore-bodies, yet examples of secondary action are quite clear in certain cases, such as at the Vermilion shaft where chalcopyrite forms veins and masses, with breccia of greenstone. Flucan and native copper in leaf form also point to leaching or segregation from the greenstone.

The section shown in Fig. 5 (Plate VIII.) will give a general idea of the occurrence of these ore-bodies. The ore is roasted in heaps after being passed through a Blake-crusher and hand picked. The heaps are usually about 6 feet high, and from 400 to 600 tons are put into a heap. The fuel used is dry pinewood, and when once thoroughly ignited the ore calcines readily. The heap burns from 30 to 50 days.

An average analysis of a roasted coppery ore is :—5·40 per cent. of copper, 2·43 per cent. of nickel, 7·92 per cent. of sulphur, 25 per cent. of iron, lime, magnesia, etc., and the residue chiefly consists of hornblende. In a non-coppery ore the copper is about one-half the nickel content.

The furnace used in smelting is a water-jacketed cupola of the Herreshoff pattern. It is nearly elliptical in form, having a longer diameter of $6\frac{1}{2}$ feet, and a shorter of $3\frac{1}{4}$ feet at the twyers, increasing in size upwards, and is 9 feet in height to the charging-door. It is made of rolled steel with a water-space of 2 inches between the outer and inner plates, and has for its bottom a cast-iron plate protected by fire-brick, the whole resting on strong iron supports. The well, fore-hearth, or settling-pot is made of double plates of cast-iron, having a water-space of 6 inches, and rests upon four wheels for convenience of moving it

whenever repairs are necessary, a second well standing ready to be put in its place. The blast is furnished by a Baker rotary blower and enters the furnace through eleven twyers under a pressure of 8 to 10 ounces per square inch. The charge consists of a mixture of calcined ore, raw ore and coke, the proportion being about 8 of ore to 1 of coke, and the slag takes off about 10 per cent. of the nickel in the ore and most of the cobalt, the slag often containing equal quantities of nickel and cobalt. The furnace smelts 120 to 150 tons per day, the proportion of slag to matte being about 8 of slag to 1 of matte. The slag is constantly discharging into pot trollies, in which it is rolled to the waste-heap. The matte is drawn at intervals through a lower tap-hole.

The matte of a coppery ore is:—

	Per Cent.
Copper	26·910
Nickel	14·140
Iron	31·235
Sulphur	26·950
Cobalt	0·235
Slag	0·935
Total	100·405

In a non-coppery ore, the nickel will run about 14 per cent., and copper 7 per cent., or where it is proposed to Bessemerize it further, the matte will be made to run about 9 per cent. of nickel and 4·5 per cent. of copper.

For shipment abroad, the matte is sometimes further concentrated by being Bessemerized in a Manhee converter, and it then runs about 40 per cent. of nickel and 20 per cent. of copper in ores which are of the non-coppery class.

No refining-works have been erected in Ontario, all matte being shipped abroad for treatment. The three principal companies operating are:—the Canada Copper Co. (who refine at Cleveland, Ohio, U.S.A.), the Vivian Co. (who refine at Swansea, Wales), and the Dominion Mineral Co., who sell their matte.

Cobalt is obtained to a small extent in association with the nickel extracted from the nickeliferous pyrrhotite.

Copper.

Copper-ores in Ontario come under three classes:—(*a*) Those connected with the large masses of nickeliferous-pyrrhotite in greenstone in the Sudbury and adjacent districts, of Huronian age. These are described above under nickel ores, with which they are associated. The deposits were opened up, at first, entirely on account

of their copper-contents, the fact that they contained nickel not having been discovered. The copper production given in the provincial statistics has entirely been derived from this source and in connexion with the nickeliferous matte. (*b*) Quartz-veins cutting Huronian rocks, chiefly greenstones, are often found to carry copper pyrites. The vein worked some years ago at the Bruce mines in the Algoma district might be taken as an example of this class of deposit. At this place, quartz-veins, varying from 6 to 20 feet wide, cut greenstone, they carry about 4½ per cent. of yellow copper pyrites and a very little iron pyrites. The section (Fig. 6, Plate VIII.) shows the occurrence of these veins. In some veins in the same district, as in the township of Gould on the Mississaba river, there is a notable quantity of copper glance, with some bornite as well as chalcopyrite. (*c*) Native copper is found in conglomerate-beds of the Nipigon series on Michipicoten Island, in Lake Superior, and at Mamainse Point, on the same lake, in the district of Algoma. The occurrence is very similar to that of the famous mines of Calumet on the southern side of Lake Superior, but no such rich beds of copper have yet been opened up on the Ontario side of the lake, though there is every reason to expect they may be found.

The rocks consist of reddish trap (sometimes porphyritic), amygdoloidal beds, volcanic tuffs, cherts, sandstones, and coarse conglomerates.

Generally speaking, the series consists of eruptive sheets and of sandstones and conglomerates, largely made up of a detrital eruptive material. The eruptives are mostly basic rocks, which were poured out as lavas upon the surface; but there are some eruptions of the acid type. The lavas and sedimentary beds are interstratified. These rocks have experienced intense and long-continued metamorphic action or alteration, which has produced amygdaloidal structure, and in certain parts has resulted an entire change in the mineral composition of the rock.

The occurrence of native copper in the conglomerates is of peculiar interest. The copper occurs both in red and green conglomerates in small veins traversing the beds at right angles to the strike and dip, in the amygdules, and in the interstices of the conglomerate. On Michipicoten, it occurs more as shot, barrel-copper, and irregular masses in the amygdaloid, in the grain form in the volcanic sandstone, and in stringers or metallic veinlets in the conglomerate, which is frequently bound together by them, especially where jasper nodules predominate.

The copper occurs in the beds in shoots dipping to the south-west, and the percentage varies from 2½ in sandstone, where it runs pre-

regular, to 10 in the best ore-shoots in the amygdaloid. Fig. 7 (Plate VIII.) illustrates the mode of occurrence at Michipicoten. It is taken from a paper by Messrs. Herrick, Tight, and Jones, on that island.

At Mamainse, the copper chiefly occurs in the form of straggling masses and thin sheets in calcspar veins crossing the formation. The conglomerate-beds are much wider, and of coarser character than at Michipicoten.

It has been demonstrated that the copper had been deposited from wet solution in the process of rock-alteration, and as a pseudomorphous replacement of certain minerals in the rocks. It is assumed that these deposits are a concentration of copper salts once minutely disseminated through the centre series, and it is probable that the original form of the mineral in these rocks was sulphide. Copper glance is found with the native copper and small veins of carbonate at Point Mamainse. The deposits are remarkable for the comparative absence of other metallic minerals except silver, which occurs to a limited extent, in the native state.

Iron.

Iron ores are developed over a very considerable extent of country, both in eastern and western Ontario. In the eastern part, the ores occur in the so-called Upper Laurentian formation, in crystalline limestones, or at their junction with other rocks, such as greenstones, and hornblendic gneisses; or again, the ores are found in greenstones. Most of the deposits discovered up to the present have been found not far to the north of the Silurian fringe.

In the western part of the province, the great iron-ranges (Vermilion and Mesabi) of Huronian age, which have been so largely developed in northern Minnesota, continue into the Thunder Bay district of Ontario, to the south-east of Port Arthur. These ore-bodies give promise of very considerable extent. At present, on the Ontario side of the international boundary, they have been only prospected in a comparatively small extent of country, and no development work to speak of has yet been done.

In the northern part of the province, Dr. R. Bell reports the occurrence of an important bed of spathic iron-ore, partly altered to limonite (containing 52·42 per cent. of iron), in the Corniferous formation, exposed on the Mattagami river towards James' Bay.

Western Iron-ores.—The ores so far discovered in the Ontario western ranges consist of magnetite and hard blue specular-ore. In Minnesota, the very best grades of Bessemer hæmatite also abound, and so favourable is their occurrence in the Mesabi range that steam-shovels are used

to extract the ore and dump it on the railway-cars, at an expense of from 50 to 75 cents per ton. As the Ontario continuation of the Vermilion and Mesabi ranges is not sufficiently developed to give satisfactory sections the author gives, from personal observation, a typical section (Fig. 8, Plate VIII.) of a deposit in the Vermilion range.

Fig. 9 (Plate VIII.) shows a section of a deposit on the Mesabi iron-range, and is taken from a paper on that subject by Mr. H. V. Winchell.

With regard to the percentage of iron in these western ores and their freedom from impurities, it will suffice to say that some of the ore-bodies already found in the Thunder Bay district are well within the Bessemer grade, one deposit of magnetite on Gunflint Lake showing a bed of 25 feet of ore which ran 68 per cent. of iron, 0·028 per cent. of phosphorus, sulphur *nil*, and very little silica. Dr. Robert Bell described a large deposit of magnetite on the Antler river lying about 100 miles west-north-west of Port Arthur, which is said to average 64 per cent. of iron, and of which he reports:—"In the widest part there are three beds, each about 50 feet in width, separated from each other by only narrow bands of rock, running with the general course of the belt to which they belong. The deposit shows workable quantities of ore at intervals for about 3 miles, and is traceable for about 5 miles."

Great interest attaches to the formation of these immense ore-bodies. There is generally an impervious bed below, and the filtration of ferruginous solution, with replacement, is the generally accepted theory. The observations of geologists of the United States Geological Survey indicate that the source of the iron has been largely the result of oceanic desposition, both chemical and mechanical, and the present ore-bodies are simply concentrations. Some of the ore-beds that have been worked in Minnesota are upwards of 100 feet thick, and from the above-mentioned facts, it would appear that there is every probability of developing large or larger bodies on the Ontario continuation of the ore-ranges.

Tributary to Sault Ste. Marie, indications exist on the eastern shore of Lake Superior and to the north of the Ste. Mary river (which joins Lakes Superior and Huron) and Lake Huron of iron-ranges similar to the Menominee and Marquette ranges of northern Michigan. The ores are, for the most part, high grade, soft specular, and red hæmatite in association with jasper.

Eastern Iron-ores.—In the eastern part of the province, about 500,000 tons of ore have been mined in all from time to time, but at present there is no ore being extracted. One blast-furnace is now under construction in the province and another is contemplated.

and there seems a probability of a revival in the iron industry in the near future, especially as no more favourable opportunity exists anywhere for manufacturing the best grades of charcoal-iron. Geologically speaking, there is little question that large and persistent ore-bodies will be opened up when there is a steady demand. The rocks and the iron-ores in them are both altogether similar to conditions which exist in Sweden, where the same sort of ores, in identical rocks, have been mined for several hundred years over a tract of country extending for some 180 miles.

In Sweden, as in Ontario, a certain amount of hæmatite (about one-tenth) is found, but the majority of the ores in both countries found in the Archæan (Laurentian) rocks are magnetites.

Moreover, the same rocks which carry the iron-ore in Eastern Ontario cross the St. Lawrence river near the eastern end of Lake Ontario, continue through part of northern New York State, and are also continued into the State of New Jersey.

The development in New York State and in New Jersey has proved that on this continent, as well as in Sweden, the iron-ore deposits in these Archæan (Laurentian) rocks are capable of development to an enormous extent. The following extract from the *Annual Report* of the Geological Survey of the State of New Jersey for the year 1882* gives a very satisfactory idea of the experience gained in connexion with the permanency of the iron-mines:—"Their permanent withdrawal and final abandonment has come not so much from the lack of ore, or the exhaustion of the veins, but from the heavy expenses attending the working of them at a greater depth," etc.

The output in 1890 was:—

	Tons.
New York State	1,253,393
New Jersey State	495,808
Total	1,749,201

And of this amount 202,035 tons were red hæmatite.

In the iron-bearing Archæan rocks of eastern Ontario, it would appear that there are two principal modes of occurrence of the iron-ores:—

(1) In association with bands of crystalline limestone, either embedded in it or at its junction with gneiss, granite, syenite, or greenstone.

(2) In greenstone, in which it occurs as irregular masses. In the latter case, the ore-body has doubtlessly been formed by differentiation, or the concentration of the ore-body in the original fused magma.

In the former case, concentration by displacement probably has played the most important part in connexion with ferruginous solutions.

* Page 70.

In certain cases, however, some of the deposits bear the character of beds deposited with the enclosing rocks, the lie of the ore-bed and the intercalated minerals being the same as that of the country rock. This would correspond with the deposits of lake-ore which are now being formed to a considerable extent in the Province of Quebec.

A large amount of hornblende or augite almost invariably accompanies the iron-ores.

The annexed section (Fig. 10, Plate VIII.) of one of the magnetic ore-beds of eastern Ontario will give an idea of the mode of its occurrence.

The grade of the ore naturally varies in different deposits. Some are very high grade and pure. In others as much as 12 per cent. of titanic acid is found. As a rule the ores are somewhat free from phosphorus, but many contain sulphur.

The following analyses of eastern Ontario ores will give an idea of a good grade of magnetite and hæmatite, the former having been shipped as a Bessemer ore, and the assay being taken from a report on the ore-body by the writer :—

	Magnetite. Per Cent.	Hæmatite. Per Cent.
Ferric oxide	63·56	82·250
Ferrous oxide	27·00	—
Silica	3·89	16·050
Alumina	0·93	
Lime	2·59	Traces
Magnesia	1·97	—
Sulphur	0·06	0·000
Titanium	0·00	—
Phosphorus	Trace	0·026
Totals	100·00	100·000
Metallic iron	65·39	57·600

Platinum.

Platinum has not yet been found in any workable amount in Ontario, but a notable quantity of a hitherto unknown compound of this and other metals of the same group with arsenic has been produced at the Vermilion mine in the Sudbury district. The compound is a heavy white metal of the following composition :—

	Per Cent.
Arsenic	4·98
Antimony	0·50
Platinum	52·57
Rhodium	0·75
Paladium	Traces
Iron	0·07
Oxide of tin	4·62
Total	99·49

The mineral has the formula $PtAs_2$, being amorphous with FeS_2, and the name sperrylite has been given to it. The mineral is found as small silver white crystals among a decomposed greenstone, which has been milled for the free gold contained in it.

Gold.

Gold has been discovered in a great many places in the ancient rocks of the province, in veins cutting syenites, granites, greenstones, and Huronian green schists, for the most part. The places where gold has been found extend from the extreme east to the extreme west of the province. Development is at present going on in only three districts, one in the east, one in the centre, and the third in the extreme west.

All of the gold occurrences are in the Huronian system, unless the measures in the east, in the Marmora district, are correctly classed as Upper Laurentian, in which case that division of the Archæan formation can claim veins of this precious metal. Another exception may also be quoted, where a quartz vein containing bornite, occurring in the Laurentian near Parry Sound, is found to yield coarse gold.

From the small amount of development which has taken place up to the present time, it would appear that disappointment in not finding an equal amount of free milling ore in depth at, or near, the surface has largely been the factor in discouraging operations. With the great advance in modern methods for treating ores of a refractory nature, we may look forward to gold-mining operations being permanently established in the province on a scale which has not hitherto been attempted.

Free milling ores, however, are by no means lacking.

The character of the arsenical gold-bearing veins in eastern Ontario, in the Marmora district, has been described under the remarks on arsenic. In the same locality, veins carrying gold in association with iron pyrites and no mispickel are also found, one of which is being developed at present. The mispickel ores appear to be more particularly associated with veins in syenite, while those veins whose chief mineral is iron pyrites seem more generally associated with diorites and talcose or chloritic schists, the latter generally as a lining to the vein.

Confusion frequently arises as to the rock in which the gold veins occur. Mining engineers, and even geologists, have failed to recognize that sometimes the schists forming the walls of the veins are the product of the chemical decomposition of the true walls, along the fissure in which the vein has formed, and this schistose lining, sometimes extend-

ing on one or both sides for some distance, is spoken of as the true wall or country rock of the vein.

The gold-bearing veins of central Ontario—the Sudbury, Wahnapitæ, and Bruce mines districts—occur in the Huronian belts for the most part in rocks of the greenstone type.

In the west, in the Lake of the Woods, Seine river, and Rainy Lake districts, the gold-carrying veins cut syenites, granites and green schists, termed Keewatin Schists, which are generally hornblendic and chloritic. Where the veins cut syenite, syenitic gneiss or diorite, there is generally a strong development of talcose schist-lining in this district. It may be said that the gold veins in the Huronian formation in Ontario are intimately connected with eruptive rocks.

The general character of the gold-bearing quartz-veins in this province is what is termed "bedded veins." The writer has, however, observed instances which would seem to point to the fact that the stratification of the formation, with which the veins run, may be a secondary or false-bedding due to pressure and metamorphic influence, and at right-angles to the pressure. This false-bedding has been caused after the vein was formed, or more probably during its formation, and the opening in which the vein has formed has also taken place at right-angles to the pressure, therefore parallel to the false-bedding. This would give the appearance of a bedded vein, even though the first crevice, in which the vein subsequently formed, was across the original bedding of the rocks or through a massive rock. In this case the designation bedded vein would be in reality a misnomer and discredit an actual fissure.

With regard to the gold-contents of the vast number of veins, which are found to carry that metal in Ontario, to a greater or less degree, a good deal could be said owing to the fact that there is naturally a great variation in richness or poverty. The arsenical ores of eastern Ontario have had examples given under arsenic. The iron pyritic ores of the same district have in one or two instances been tested pretty extensively. A good average of them may be said to be 10 dols. a ton, while one mill-test of 3 tons of ore by Messrs. Ricketts & Banks, of New York, was said to yield 25·40 dols. per ton, and assays of iron pyrites gave from 90 dols. to 326 dols. per ton.

In central Ontario, in the Bruce mines district, the milling operations at the Ophir mine are said to be profitable, but the true yield is not generally known. Three lots of ore (presumably picked) were treated at the Houghton School of Mines and gave an average of 9·7 ounces of gold and 6·15 ounces of silver per ton.

In western Ontario, in the Lake of the Woods and Rainy Lake districts, extremely rich samples of ore have been found near the surface, but until lately no veins had been developed which did not become refractory in a very short distance down, in some cases running into mispickel. Recently, however, mining and milling operations indicate that the free milling stage continues to a considerable depth in some of the veins, and that a yield of 10 dols. and upwards per ton is obtained from the mill.

In one instance, however, the Sultana mine has been producing ore from below 200 feet in depth, which has recently been milling as high in free gold as from 15 dols. to 25 dols. per ton, with concentrates running from 40 dols. to 80 dols. per ton. The ore is taken from a vein running with the formation, and the quartz occurs as lenses in a belt of talcose-lining. When one lens is worked out, another is opened up by sinking or drifting. The country rock in this case is a porphyritic quartz-syenite in which mica is also developed, and the felspar greatly preponderates. It shows signs of considerable pressure, a fissile or schistose structure, and elongation from squeezing being abundantly visible.

The gold-belt which is exciting the greatest interest at present is situated on the Seine river, Rainy river district. Though no mines have yet been opened, extensive prospecting and preliminary works are being carried on with encouraging results. The chief area, so far discovered, shows a great number of strong auriferous quartz veins cutting a granite which varies in different parts of the area from true granite to binary, hornblendic and protogenic types. So far as worked out the richest veins seem to be connected with the protogene in which chlorite and talc, in the place of mica, gives the rock a greenish hue; iron pyrites is also common in this granite. The gold is very coarse and the higher grade ore gives excellent panning results. The concentrates in some instances run very high. Iron pyrites, galena, and zinc blende are the chief minerals in the veins, and the gold is apparently more often intimately associated with the occurrence of the blende than with either of the other minerals.

The strike of the veins is generally from north and south to east and west, and often north-westerly. Fig. 11 (Plate VIII.) gives a rough section and general idea of the belt above described.

In the western part of the Thunder Bay district, a vein in a dioritic rock was worked for sylvanite, but though the ore was said to run 21 dols. to the ton, the enterprise was not a success. This is mentioned, as it is the only place where this mineral has been obtained in the

province. In the township of Marmora, Hastings county, bournonite is found carrying 1·45 ounces of gold and 4·37 ounces of silver per ton.

In conclusion, it may very properly be said that there is every reason to believe that with the requisite amount of capital invested in judicious development, and in some cases with the best modern methods and machinery for extracting gold from refractory ores, gold-mining will become a very important and remunerative industry in Ontario.

Silver.

Silver-ores have only been produced to any extent in one district in Ontario. Near Port Arthur, in the Thunder Bay district, well defined fissure-veins cut the black Animikie (Cambrian) shales and trap overlying (and in places forced in between) the shales. These veins carry silver-ore in irregular shoots and ore-bodies, varying from mere traces up to several thousands of dollars per ton. The crevice in which the vein has formed has generally faulted the series. The line of fault, and presence of a vein, may often be noticed by an indentation in the escarpment, visible for miles away, but it is only where a capping of trap has prevented the weathering down of the soft shales that an escarpment has formed and the veins have been made visible thereby. Sometimes, however, the veins cross intrusive vertical dykes, as at Silver Islet, and they are there visible. Figs. 12 and 13 (Plate VIII.) are examples of these conditions.

The veins strike in different directions, but the majority run east and west. None appear to have any decided advantage over the others on account of the direction of their course, although, of the richest developed thus far, Silver Islet strikes north and south, and the Beaver and Badger north-easterly. For the most part the veins are very strong and persistent. As an example the Walbridge or Trowbridge vein is known to run from 12 to 15 miles, and in places it widens to some 50 feet. The veins not only cut the Animikie formation and the overlying trap, but they extend down into the Archæan below. This is shown in one case at the Shuniah mine, where the vein cuts into a granitic syenite in the lower levels; and again at the Silver Mountain West-end mine where the shaft followed the vein into the underlying Huronian jasper. In neither of these cases has the Archæan proved a prolific wall-rock.

The components of the veins are chiefly calcspar, quartz (commonly as amethysts), fluorspar, heavy spar, and breccia of wall-rock. The minerals which they carry are iron pyrites, galena, zinc-blende, with native silver near the surface and argentite below. The galena is not

argentiferous as a rule, but the zinc-blende is often rich in silver, which is held in leaf-form through the blende. The rarer silver minerals which were found, more particularly at Silver Islet, contain nickel, cobalt, and arsenic, and are known as macfarlanite, huntalite, and animikite, the latter having also a little antimony. It is also said that arsenical silver-ore has been found on Edwards Island in Black Bay, antimonial silver-ore on an island at the mouth of Pine Bay, township of Pardu, and tetrahedrite in another locality. The silver-contents of the veins occur in very irregular pockets in some mines and in shutes in others. In the Silver Islet mine, the ore was associated with the occurrence of graphite, the presence of which was constantly watched for. In this mine there were pockets of gas, which sometimes became ignited. Ore was shipped from the mine of a value of 1,000 dollars, 3,000 dollars, and up to 5,000 dollars a ton. While in operation, the mine produced over 3,000,000 dollars in silver, but, after the prospectors had been unsuccessful in striking a new pocket of ore for some time, a gale on the lake flooded the mine, and it has not been since pumped out and worked. The best ore from the other mines has been shipped running 1,000 dollars and 1,500 dollars a ton. Lower grade ores are stamped and concentrated. No smelting has yet been done in the district, and at present, owing to the low price in silver, no mines are worked.

There is no question that silver-mining will be carried on profitably in the future, as has been the case in the past, and on a very much increased scale in this district.

A silver-ore of an unusual character has been discovered and prospected to a limited extent in eastern Ontario. The ore appears to be an argentiferous meninghenite, the silver being more probably associated with the lead than with the antimony, for it is stated that specimens of stibnite found with the ore were devoid of silver. This ore appears to occur in veins or stringers in connexion with a strong bed of crystalline limestone, of Upper Laurentian age, which can be followed for miles.

Lead.

Lead ores have been worked in both eastern and central Ontario, but the ventures were not successful. In the east, veins carrying galena, considered at one time to be in paying quantities, cut the Upper Laurentian, and also the Calciferous formations. In the former, the country rock is gneiss and crystalline limestone, and in the latter a dolomitic limestone. In both cases the silver-contents of the ore was low. The vein-matter consists of calcspar, and on an average about 5 per cent.

of galena, containing some 4 dollars in silver per ton, is scattered in irregular bunches through the vein-matter. A little barytes, iron, and copper pyrites and blende are also found in small quantities in the vein-matter.

In the central part of the province, near Sault Ste. Marie, veins of argentiferous galena were worked to a depth of 400 feet. The ore is said to assay, on the average, 20 dollars of silver and 60 per cent. of lead per ton. The galena occurs in veins and stringers in a belt of green schists, which lies between granite and a siliceous felsite, with hornblende-rock, of Huronian age. Zinc-blende and copper and iron pyrites occur with the galena.

In the west, the silver-carrying veins of the Animikie contain sometimes considerable quantities of galena, but no mine has been worked for the latter mineral. Galena-bearing veins occurring in Laurentian and in the Nipigon series, are also found in the Thunder Bay district, opposite the head of Black Bay (Lake Superior), south of Lake Nipigon. One of these veins, with a width of 6 to 8 feet, was worked for the galena. It was said to carry 17 dollars of gold and 2 dollars of silver per ton. The gangue is quartz, calcspar, and barytes. It is not now worked.

Zinc.

Zinc-ores are not worked in the province, either for export or for the extraction of the zinc. Zinc-blende is reported to have been found to a considerable extent in the Huronian formation, in a hornblende-rock or diorite, occurring in large veins or lenticular masses at the Zenyth location, Black Bay, near Thunder Bay. It gave an assay, according to the records of the Geological Survey, of 54 per cent. of zinc. The same ore in large crystals is found in an 8 feet vein of coarse calcspar, which occurs at the contact of the Huronian and Animikie rocks. The blende occurring in the silver-carrying veins of the Animikie has been alluded to.

Apatite.

Phosphate of lime or apatite has not been found in Ontario in as large deposits as in the sister province of Quebec, but as regards similarity of occurrence and quality of produce (dependent largely upon intelligent dressing of the rock) identical conditions appear to prevail on both sides of the Ottawa river. Apatite averaging 84 per cent. of phosphate of lime has been shipped from Ontario mines.

At present the low price of phosphate of lime, owing to the development of the Florida high-grade rock, has been the cause of the temporary

cessation of this industry in Ontario. The apatite-bearing formation is found so far only in the extreme eastern portion of the province.

The apatite occurs in veins, usually bedded veins, in pyroxenite and gneisses in the Laurentian system; hornblende or pyroxene and mica invariably are present with the apatite, and the former is sometimes mistaken for it. Sometimes the apatite is found in the form of crystals in veins of calcspar, but these deposits are not usually so remunerative as the more massive occurrence, though the uncertainty and irregularity of all phosphate-veins is exceptionally great. The following sketch (Fig. 14, Plate VIII.) of a phosphate-vein gives an example where it cuts across the formation, though it is usually found running with it.

Much of the mining in Ontario is in reality quarrying, and is done by means of open-cuts. Where this is the case, the apatite is taken out in fairly solid condition, but when a great depth is reached the force of the strong explosives, that it is necessary to use in the very hard rock in which the apatite occurs, breaks the apatite into a powder, in which form much of the high grade is shipped from deep mines. The product is dressed and sorted into three grades usually, only the first two being shipped. Grade No. 1 runs over 80 per cent. of phosphate of lime.

Mica.

Mica-mining may properly be said to be in its infancy, and until quite recently had nowhere arrived at the dignity of mining, the operation consisting for the most part in making irregular surface-pits where the mica-crystals were discovered at the surface. This condition was chiefly due to the fact that the consumption of the mineral was very small. Electricity has, however, brought about a much larger demand for mica, and it is expected that mica-mining will assume considerable importance in the near future.

The mica-bearing formations of eastern Canada occur in the Laurentian. Nearly all of these old crystalline rocks carry more or less mica, but only in certain belts is mica found in large enough crystals to be of commercial value. Mica occurs in two classes of rocks:—

(1) *Granite.*—In granite the mica is associated with quartz and felspar, and is usually present as muscovite or white mica. Other minerals, such as tourmaline, garnet, apatite, and common emerald, are very often found in a crystalline form associated with this class of deposit.

It is evidently where the crystallization of the rocks has been slowest that we find the merchantable mica, for the other components of the

rock accompanying it are also more or less equally well-developed, and we not only find larger crystals of mica but the crystals of the other minerals composing the rock are of a correspondingly increased size. It is therefore advisable to note the general crystalline character of the rock-masses when mica-crystals appear at the surface and mining operations are contemplated.

(2) *Hornblendic or Pyroxenic Rock.*—The largest quantity of mica, however, is obtained from hornblendic syenite, often gneissic, but in cases graduating from a pyroxenic syenite to a diorite or gabbro. In this latter class of deposit, the mica is either found associated with hornblende or pyroxene and apatite, or in veins or irregular masses of calcspar or felspar (with more or less quartz) cutting hornblendic or pyroxenic syenite.

The mica is chiefly found as phlogopite or amber mica, but sometimes biotite or black mica is found. It may be remarked that where the hornblende contains a larger quantity of iron (typical black hornblende) the mica is darker, and when the mica is associated with the lighter coloured actinolite it is found to be amber-coloured or almost white.

Fig. 15 (Plate VIII.) is a section showing a large deposit of the second class of occurrence worked in the Kingston district. Crystals 6 feet across were to be seen in the zone marked *a*.

It may correctly be inferred from the above description that the occurrence of the larger (or merchantable) crystals is somewhat irregular and precarious, and such is found to be the case. Indeed, in most formations, the crystals are much twisted, broken by joints, with embedded crystals of quartz or calcspar, and sometimes spotted with iron or manganese stain, or minute crystals of tourmaline, magnetite, apatite, calcite, etc.

It is perhaps more difficult to put a price upon the cost of mining mica than upon any other mineral, though it be conceded that all mineral occurrences vary greatly in the cost of their yield. When the mica is associated with apatite, as is very often the case, that mineral yields a good price, and the felspar, which is in other cases largely developed in association with the mica, has been exported; but the extensive use of this mineral at remunerative prices to the producer, remains for further developments. Under exceptionally favourable cases, 20 tons of rock may yield a ton of merchantable uncut mica, and it in turn gives a very good result if from 4 to 10 tons of the uncut mica yield 1 ton of cut mica. In one case in a yield of 23 per cent. of cut mica, 7 per cent. was No. 1 and 16 per cent. was No. 2. Sizes run from 6 by 7 inches down

1½ by 2½ inches, the smaller sizes being much the most numerous. It is a somewhat strange coincidence that 23 per cent. is the exact yield of a well-known Indian mine.

Graphite.

Graphite or plumbago is not at present mined in the province, but a deposit in eastern Ontario was worked somewhat extensively many years ago.

The plumbago is found in the Laurentian formation, occurring, where worked, in thickly disseminated scales in a sandy, calcareous and quartzose rock (gneissic in structure), which in some places graduates into an impure limestone. Large amounts of this graphite-rock are obtainable at a low cost, but the presence of the lime probably accounts for its now being unworked. The rock was stamped in a 10 stamp mill, and the plumbago washed out on 3 revolving buddles. The resulting powder was dried and bolted.

Natural Gas.

Natural gas has been found in important quantities in two places in Ontario, both on the northern shore of Lake Erie. The first place, where it was found by boring, was at the extreme western tongue of the peninsula of Ontario. Here it was found in the Clinton formation, and the flow occurred from a vesicular limestone. It is well established that one of the principal reservoirs of the gas is in spaces which have been caused by dolomitization of limestone. However, the cause which led to the search for gas at this place, was because it was in the line of the continuation of the great anticlinal of Ohio, which had been proved to be such a wonderful reservoir for gas in that state. The flow when first struck went as high, in different holes, as from 2 to 10 millions of cubic feet of gas per day, with a pressure of 400 lbs. per square inch. The holes are bored about 1,000 feet deep in this gas-field.

The second place, where large quantities of gas were found, was at the eastern end of the southern part of the peninsula of Ontario, no great distance from where the Niagara river flows out of Lake Erie. In this district, the gas was found also in the Clinton rocks, but the main supply is derived from still lower down, from the Medina shales and sandstones. Here the pressure amounted to 500 and 560 lbs. per square inch, and the yield reached from 2 to 3 millions, and upwards, of cubic feet of gas per day. The depth of the holes are, to reach the Clinton about 680 feet, and the Medina formation about 750 feet, and this latter is penetrated generally to some 850 feet.

To give an idea of the cost of drilling, a fair average price down to a depth of 850 feet would be about 2 dollars per foot, including casing, and a completed well in all respects.

The great pressure of the gas of the wells is reduced by regulators down to 4 or 5 ozs. per square inch at the consuming point. Unfortunately, the gas is being rapidly exhausted, especially in the eastern field which supplies the large city of Buffalo, in the United States, and the pressure is getting less and less, so that it has become necessary to use pumps to force the gas, instead of being obliged to call into play considerable ingenuity to control it.

This natural gas is an object lesson of the different policies which animate the two Anglo-Saxon races of the North American continent.

The Ontario gas-field is being exhausted for the benefit of the people of New York State, without let, tax, or hindrance on the part of the people of Canada, while a washerwoman, and much less a miner, is not allowed to cross the international line and seek work in the United States while domiciled in Canada.

Petroleum.

Petroleum is found in two areas in the western part of the peninsula of Ontario in the county of Lambton. The rock which furnishes the oil is the Corniferous limestone (Devonian) which is very fossiliferous. The oil is struck at between 465 and 475 feet from the surface in a porous dolomitic limestone, which is from 1 to 6 feet thick, brown in colour (probably from the petroleum), and very soft. The holes are drilled 4⅝ inches in diameter, and where casing is put down it is rimmed out ½ or ¾ inch more, the casing being 4⅝ inches inside and 5⅛ inches in outside diameter. The hole is put down in about five or six days, and costs, for drilling, from 150 to 160 dols. Wooden rods are used as drill-rods, in place of the rope used in the United States oil-districts, a steel drill 3½ inches in diameter and 25 to 30 feet long being attached to the lowest section. These Petrolea drillers are very expert, and are called for all over the world, much work being done by them in Europe, Asia, and Australia. The oil was at first free-flowing, but in this field it is now pumped and run into tanks. The crude-oil is distilled in large sheet-iron retorts, and the various products are:—Gasoline, naphtha, illuminating oil, intermediate and wool oils, and, lastly, lubricating-oils; while incrustation of carbonaceous matter or coke, which makes a good fuel, is left in the retort.

All the grades of distillation are divided at will, either by stopping the process at various stages or by subsequent re-distillation and treatment

an almost endless variety of lighter and highly combustible inter-
ate illuminating and lubricating-oils, and also into such solids as
ine, paraffin, etc. Tars and asphalts might be produced from an
zed matter which is thrown away.

he products of evaporation may be roughly divided into 40 per cent.
uminating-oils, and 60 per cent. of the above-mentioned articles;
ore exactly, burning oil 38 to 39 per cent., gas oil 17 per cent., tar
r cent., waste 10 per cent., water 6 per cent., and coke 9 per cent.

he fire-test of 95 degs. Fahr., at which the oil ignites, is common to
ades of illuminating-oil.

he process of refining the illuminating-oil is to agitate it with 2 per
of sulphuric acid to remove the free carbon or tarry materials which
awn off below; then, after washing it with water, caustic soda and
ge are added. The litharge combines with the sulphur present in
l and forms lead sulphide. Flowers of sulphur is then added, which
itates the lead and other impurities, and the oil is left cleared, but
sulphur generally remains. This sulphur gives the oil a smell in
ng, and it is removed by some refiners by re-distilling the oil after
charge and caustic soda have been added, and before the flowers of
ur has been put in. Most of the sulphur is then left in the retort
mbination with the lead. The rest of the process is then carried on
the re-distilled product as above described. Finally, in all processes
roduct is bleached in the light in an open vat.

he tar, or residue after the illuminating-oils have come off, is re-
led, from which about 70 per cent. of gas oil, used in making illum-
g gas, and 30 per cent. of paraffin oil are obtained, according to
ade required. The paraffin oil is put into a freezing-vat, and from
0 per cent. (or one pound to the gallon) of paraffin wax crystallizes
om it. This wax has all the oil squeezed out by pressure and is
l, one part of the resulting yield being made into wax candles, and
her smaller portion into a wax which is used as chewing-gum and
rious other purposes. The residual oils, after the paraffin has been
lized, are made into lubricating-oils.

uminating-oil can be distilled from the Utica shales, which, in
contain 3 to 4 per cent. of tarry oil. This industry, however,
compete with the petroleum oil-fields.

Lignite.

gnite has been found in unproved quantity in the north on
issinaibi and Mattagami rivers, branches of the Moose river.
s also been met with on Rainy river. All the occurrences so far
been in the drift.

The writer now concludes a condensed and necessarily in description of the economic minerals of Ontario. As will be gath his remarks immense possibilities exist for enormous future deve

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Mr. J. H. MERIVALE moved that votes of thanks be accord North Staffordshire Institute of Mining and Mechanical Engi the arrangements they had made for the reception of the mem to Col. Strick and the officers of the First Shropshire and Staf Artillery Volunteers for the use of the room.

The votes were agreed to.

Mr. H. R. MAKEPEACE proposed a vote of thanks to the l for his able conduct in the chair.

Mr. T. E. STOREY seconded the resolution, which was carrie mously.

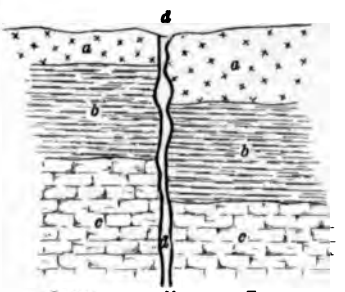
The meeting was then closed.

The following notes record some of the features of interes visitors to works and collieries, which were, by kind permissic owners, open for inspection during the course of the meeting on ber 18th and 19th, 1895 :—

FIG. 5.

a, GRANITE.
b, GREENSTONE.
c, MIXED GRANITE AND GREENSTONE.
d, ORE-BODY.

FIG. 12.



SECTION OF A VERTICAL FAULT.

a, TRAP.
b, BLACK SHALES.
c, CHERTY LIMESTONE.
d, VEIN.

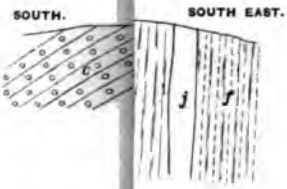


FIG. 10.

STONE.
AND HORNBLENDIC SCHIST (GREEN).
ST WITH ORE-STREAKS.
ODY, BANDED STRUCTURE WITH
S.
RTZ.
NDIC ROCK, QUARTZOSE IN PLACES.
GNEISS.

FIG. 15.

a, ZONE OF LARGER CRYSTALS OF MICA AND HORNBLENDE.
b, APATITE AND HORNBLENDE.
c, CHIEFLY HORNBLENDE.
d, MICA ROCK.

HANLEY ELECTRIC LIGHT STATION.

The installation consists of four Mordey alternators, two of these have a capacity of 50 kilowatts, and two a capacity of 100 kilowatts each. The machines are driven by four compound Brush vertical engines, two of which are of 100 horse-power, and the other two of 200 horse-power each.

Two Victoria Brush continuous-current exciters are driven by belts, each from one of the 50 kilowatts alternators.

The Lancashire boilers are 28 feet long by 7 feet in diameter, working at a pressure of 120 pounds per square inch.

MESSRS. DOULTON & CO.'S WORKS, BURSLEM.

The members were conducted to the clay-sheds where the various clays could be seen, these are mixed in proportions to form the "bodies" required after being reduced in conjunction with water in the "blungers" to a consistency weighing so many ounces to a pint of the liquid. A quantity of ground liquid flint, also tested by weight, is added to give the body hardness; the impurities are removed by passing the mixture or "slip," as it is called, through brass-wire sieves called "lawns," which consist of 100, 120, 130, and often of 140 wires to the inch, and past magnets to remove all particles of metals. Colours which are ground in granite-mills are passed through silk "lawns" of 180 threads to the inch, or 32,400 apertures to the square inch. The slip is then forced into presses by means of force-pumps until a pressure of 90 lbs. per square inch is reached: the slip has now become clay, the water having all been forced away by the pressure, and it is then passed through a pug-mill to give density to the clay, and is then ready for the potter.

The visitors thence passed to the workshops, which are named as follows:—Flat-pressers, towing, throwing and turning (the dust from these shops is removed by centrifugal fans), handling, casting, and pressing; thence to the bisque oven, where, after being placed in "saggars," the ware is fired, which process usually occupies 60 hours.

The bisque warehouse was next reached, where the ware is all examined before passing to the next process. In this state the ware is usually printed, and then passes to the "dippers." The ware is here dipped in the "glaze," then dried, and after again being placed in "saggars" is fired in the "glost" oven (this firing usually takes from 27 to 32 hours).

The visitors then passed to the decorators' shops. Here the printed-ware receives its colourings, called "filling-in." The plain-ware is gilded or painted according to the designs of the manufacturers, in the studios of the principal artists, namely, Messrs. Mitchell, Wilson & White; Messrs. Hancock, Bilton, & Slater; and Messrs. Dewsbury & Allen, where the artist has free scope given to his imagination and skill.

MESSRS. JAMES MACINTYRE & COMPANY'S WASHINGTON CHINA WORKS, BURSLEM.

The members were shown the raw materials, the making up of the same into plastic clay, the different methods of forming the clay, technically known as "throwing, turning, pressing, and casting," the placing of the same in ovens, and the subsequent glazing of the biscuit ware and firing. The decorating and gilding departments and ware-houses were also shown to the members, together with the making of finished ware known as Washington *faïence*, sign-board letters in porcelain, many articles of toilet-ware, including ivory hair-brushes, scent bottles in imitation of eggs of wild birds, beautifully variegated in perfect reproduction of their natural colours, walnuts, etc., agate ware, and electrical appliances.

THE SNEYD COLLIERY AND BRICKWORKS.

The No. 1, or upcast, shaft is 12 feet in diameter and 1,836 feet deep to the return air-cruts. The No. 2, or downcast and winding shaft, is sunk to the depth of 1,864 feet to the insetts, whence cruts pass east and west to six coal-seams :—the mossfield, yard, and main coal-seams on the west, and the bowling alley, holley lane, and hard mine coal-seams on the east. The holley lane and yard coal-seams, each 3 feet thick, are worked by the spunney system, recently described by Mr. John Heath.* The No. 3 downcast and winding shaft is 1,140 feet deep, and communicates with the burnwood, mossfield, two-feet, and seven-feet coal-seams.

The No. 2 winding engine has two horizontal cylinders, each 36 inches in diameter and 6 feet stroke, fitted with Melling steam reversing-gear and Woodworth automatic progressive cut-off gearing. The

* *Trans. Fed. Inst.*, vol. ix., page 226.

cylindrical drums are 21 feet in diameter and 7½ feet wide. The engine is capable of raising 1,200 tons from the depth of 1,864 feet in 8 hours.

The No. 3 winding engine has two horizontal cylinders, each 16 inches in diameter by 4 feet stroke, and is capable of winding 800 tons in 8 hours from the depth of 1,140 feet, owing to the use of the Kœpe system of winding.

Locked lamps of Mueseler type (bonneted) are used, adapted to burn petroleum by the Heath and Frost petroleum-burner for safety-lamps, the cost being only about half that of prepared colza oil and the light much better. About 1,200 lamps are in use at the colliery.

Tonite is the explosive used, surrounded by a gelatinous cartridge, the contents of which are liquefied by the explosion, thus destroying any flame or fumes that might otherwise arise. The shots are lighted by the Heath and Frost shot-firing lamp, by which the fuze is ignited in a completely closed chamber.

Four shaker-screens of the bar type are in operation at the truck-sidings, and a picking-band by which the coal is carefully sorted. Heath and Woodworth through-way end-tipplers are used; these, with the elevator, screens, and picking-bands, are driven by an horizontal engine with two cylinders, each 8 inches in diameter.

The trucks, when loaded, gravitate from the screens to the sidings, the gradient being 1 in 30. A stationary hauling-engine with two cylinders 12 inches in diameter by 4 feet stroke, fitted with a drum 10 feet in diameter and geared 5 to 1, is used to bring the empty trucks to the screens. The sidings are connected with the North Staffordshire Railway Company's loop line.

Steam is generated in six Lancashire boilers, each 30 feet long and 7 feet in diameter, and two elephant boilers, all worked at a pressure of 90 lbs. per square inch.

The head-gear (56 feet high) of the No. 2 shaft is made of steel H girders.

There are three underground hauling-engines, driven by steam generated in underground boilers. The furnaces and the exhaust steam of the underground engines produce a ventilating current of 100,000 cubic feet of air per minute, under a depression of 1·4 inches of water in No. 2 pit, and of 68,000 cubic feet of air per minute under a depression of 1 inch of water in No. 3 pit.

The surface-haulage, on an incline 1,800 feet long, is worked by means of an electric motor of 3 horse-power, and nine coal-tipplers at the land-sale wharf are driven by another motor of 1 horse-power.

The electric plant includes two dynamos of 15½ kilowatts each, driven by two horizontal engines.

There are four dip pumps and one shaft pump. The latter pump, placed at the bottom of the No. 3 shaft, has a steam cylinder 26 inches in diameter by 4 feet stroke, and works a double-acting ram-pump 7 inches in diameter. These pumps and the water-tanks control the whole of the water.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
DECEMBER 14TH, 1895.

MR. THOMAS DOUGLAS, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting and reported the proceedings of the Council on November 30th and that day.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. JOHN W. AINSWORTH, Mine Surveyor, Bridgewater Trustees Collieries, Walkden, Bolton, Lancashire.

Mr. GEORGE F. BEARDSLEY, Chief Assayer, The Mount Lyell Mining and Railway Company, Limited, Mine Office, Mount Lyell, Tasmania.

Mr. LOUIS P. BOWLER, Mining Engineer, P.O. Box 105, Barberton, South Africa.

Mr. ANDREW WHITE CROOKSTON, Mining Engineer and Owner of Phosphate Mines in Algeria, 19, Wellington Street, Glasgow.

Mr. JOHN DAW, Jun., Mine Owner, Mine Manager, and Mining, Civil, and Metallurgical Engineer, Brooklands, Rosemont Road, Acton, London, W.

Mr. WALTER FLETCHER, Mining Engineer, Ladyshore Colliery, Little Lever, Bolton, Lancashire.

Mr. JOHN DANIEL FROSSARD, Mining and Consulting Engineer, 5, Courtenay Road, Waterloo, Liverpool.

Mr. HENRY LIPSON HANCOCK, Engineer, Moonta Mines, South Australia.

Mr. J. P. K. MILLER, Chief Engineer, H. C. Frick Coke Company, Scottdale, Pennsylvania, U.S.A.

Mr. CORNELIUS MCLEOD PERCY, Mining and Mechanical Engineer, King Street, Wigan.

Mr. ARTHUR PERNOLET, Ingénieur Civil des Mines, 87, Rue Lafayette, Paris, France.

Mr. JAMES ROBERTS, Jun., Mining Engineer, Perranporth, R.S.O., Cornwall.

Mr. F. BOWES SCOTT, Mining Engineer, Coolgardie Chambers, Coolgardie, Western Australia.

Mr. FRANK SIMON, Underground Manager, The Great Eastern Collieries, Limited, Springs, S.A.R.

ASSOCIATE MEMBERS—

Mr. GEORGE HEELEY, 34, Oxford Street, Sheffield.

Colonel LAWRENCE HEYWORTH, Ormsby Hall, Alford, Lincolnshire.

Mr. THOMAS ALOYSIUS O'DONAHUE, 35, Princess Street, Wigan.

Mr. JOHN W. PLUMMER, Delamar Mining Company, Limited, Delamar, Owyhee County, Idaho, U.S.A.

Mr. JOHN HOWARD TAYLOR, Coolgardie, Western Australia.

STUDENTS—

Mr. THOMAS V. SIMPSON, Mining Student, Heworth Colliery, Felling, R.S.O., Co. Durham.

Mr. STEPHEN SOUTHERN, Mining Student, Heworth Colliery, Felling, R.S.O., Co. Durham.

DISCUSSION ON MR. F. G. MEACHEM'S PAPER ON "POISONING OF HORSES BY *LATHYRUS SATIVUS*."*

Mr. J. P. KIRKUP wrote that a magnified illustration of the *Lathyrus sativus* would facilitate its identification in any sample of imported equine food grains; and it would relieve the minds of those who, induced by motives of economy, feed their mining studs on cheap foreign grains. He (Mr. Kirkup) would not condemn indiscriminately all imported grains, but no doubt unscrupulous dealers would not hesitate to ship stuff which was unsaleable where grown owing to its contamination, in the expectation that it would be sold in countries unfamiliar with the deleterious constituents. During his (Mr. Kirkup's) residence in India, he did not meet with any case of *Lathyrus*-poisoning, although he fed his own horses with the native food grains, *gram* and *kulthee*, the former a species of pea and the latter a vetch. From what Mr. Meachem reports one would have been led to expect the latter grain to afford a medium of conveying the poisonous one. *Kulthee*, owing to its extremely tough skin, requires to be steeped in water for a considerable time, or partially cooked by boiling, otherwise it would be bolted whole and set up symptoms of indigestion. *Gram* is without doubt a splendid grain for horses, and if imported into this country would afford a cheap and work-supporting food. He (Mr. Kirkup) would add with reference to Mr. Meachem's paper on "Horse-feed"† that the tables afforded an illustration of vagaries in the feeding of pit-horses. Some of them might be improved under the influence of a visit from the Society for the Prevention of Cruelty to Animals. Mr. Meachem's model feed almost coincides with the regulation allowance in cavalry stables. He

* *Trans. Fed. Inst.*, vol. x., page 183. † *Ibid.*, page 188.

objected to the daily use of bran, and had with advantage confined its use solely to the administration of a mash at the end of the week to each animal. He could recommend Lieut.-General Sir F. Fitzwygram's book on *Horses and Stables* as a guide to colliery managers in the care of horses and ponies.

Mr. CLEMENT STEPHENSON (Newcastle-upon-Tyne) wrote that Mr. Meachem's paper fully covered what was known upon the subject. He might, however, direct attention to the following sentence:—"It is very doubtful if a horse, once affected, ever regains health."* This statement agrees with the general opinion upon the subject; and Mr. Smith, in his *Veterinary Hygiene*, second edition, page 157, states that "both animals and man are affected by it, and the disease is incurable." In 1894, he (Mr. Stephenson) had the opportunity of examining several horses in this district that were suffering from *Lathyrus*-poisoning—some died, and others could only be kept at work by the aid of tracheotomy-tubes. Mr. William Hunter, the veterinary surgeon in attendance, stated recently that the horses affected had all recovered. He (Mr. Stephenson) thought that it should be known that cases do recover, but as the poison is a cumulative one the recovery is necessarily a slow process.

Mr. W. HUNTER (Newcastle-upon-Tyne) wrote that he found, on making particular enquiries concerning the horses which suffered from *Lathyrus sativus*-poisoning, that they had not entirely recovered from its effects as he expected. They had greatly improved in their breathing, and work daily without distress. The tracheotomy-tubes were removed some months ago.

Mr. HUNTING said that Mr. Meachem appeared to have stated all that was generally known about *Lathyrus*-poisoning. He had used the pea or vetch, *Lathyrus sativus*, for the last twelve years, and never saw any injurious effects from its use. It was an exceedingly rich food, and had a marvellous effect on the nervous system of animals, both on men and horses. It should be given in small quantities (about ¼ peck to a sack each of maize, beans, and oats), or one part of corn provender to 48 parts of the three just mentioned, and as hay is mixed with the 48 parts, in the ratio of 1 stone of hay to 2 stones of corn, the quantity used per day is very small. He had used 50 quarters last year for feeding horses at South Hetton and Murton collieries, and 50 quarters for cattle, sheep, and horses, on the farms, without any objectionable symptom being seen. He had supplied 350 quarters to more than 2,000 animals

* *Trans. Fed. Inst.*, vol. x., page 186.

in 1894, and he had never seen a single symptom of poisoning. If, therefore, *Lathyrus sativus* was so poisonous, it must be on account of its cumulative properties in the system and the very large quantities that were given. This pea might act in exactly the same manner as opium did on human beings; a single grain would be quite enough for those who were not used to it, but there were men who could take 2 drams a day. He (Mr. Hunting) did not use more than ½ pound of *Lathyrus sativus* per head per day, about the same proportion as he would use of English or Dutch tares, as they were very astringent.

Cavalry veterinary surgeons in India were well acquainted with the paralytic effects of *Lathyrus sativus* on the muscles of the larynx of horses. As far as he could learn, this poisonous pea was not cultivated separately, but was found mixed with *gram*, which constitutes 95 per cent. of the corn-food of horses in that country. We often find tares mixed with field-peas in England or with oats in Germany, and in the same way, as the result of negligence on the part of the sower, *Lathyrus sativus* is found mixed with *gram;* but unless sown in large quantities, he doubted whether it would ever be found injurious to horses or cattle. So far as he could ascertain from officers in the Indian army, the effects were only seen in special localities; thus Colonel Arthur, who was in India very many years, and who kept five or six horses, never saw the disease, although all his horses were fed for years only on *gram* and grass; and Captain T. P. Gudgin, who was ten years in India, never saw the disease, although all the cavalry horses only had *gram* and grass for provender; oats or hay were never used as a general food for the cavalry horses of the Indian army. The dog-toothed pea, or *muttra*, was a very different grain to *gram*, and was not grown in any large area for the purposes of sale, but it was much used among the poor in India. *Lathyrus sativus* is generally known in England as the "square-headed" or "dog-tooth" pea, because it is flat-sided, and not round like a European or Canadian pea. It is grown in India, Persia, Spain, and Southern Russia, and varies in colour from a fawn to a dark brown, and the size varies as much as the colour, some being as small as the smallest Indian tare, or *gram*,* which is less than half the size of the Spanish or Morocco *gram*.

* Mr. Hunting exhibited samples of *Lathyrus sativus* as used by the Bristol Tramways Company and at a colliery in Northumberland, together with a sample that he had purchased in the market at Biskra, in the Algerian Sahara, where he saw many people eating them from their pockets; he was told that a man could perform long journeys with no other food than a handful of these raw peas and a few dates.

The worst outbreaks of disease, the result of eating these peas, occurred in Liverpool in 1885, and in Bristol in August, 1894. Many horses suffered in Newcastle last year from eating them, because the owners of the horses gave ten times as much in each day as he (Mr. Hunting) had done.

At one colliery in Northumberland, where his (Mr. Hunting's) opinion had been asked, in August, 1894, the following mixture was supplied to the horses:—Square-headed peas, 42 parts; maize, 38 parts; and oats, 20 parts. In one week the horses and ponies were falling, stumbling, and gasping all over the pit, and 5 died (the owner had been told not to give more than a tithe of the quantity used in the feed, but he persisted in giving it). As soon as the stud was seen by the veterinary surgeon, the supply of peas was instantly stopped, and after an interval of a week or ten days he was told that no evil symptoms were seen. He (Mr. Hunting) told the veterinary surgeon that the quantities used were excessive, and he replied that "beans were extremely valuable for horses, and he could not see the difference between using 42 and 22 per cent." He had been consulted in two cases of poisoning in regard to a cargo of *Lathyrus sativus*, a portion of which he had used. One was with the horses belonging to Messrs. Leatham, of Liverpool, and out of 200 or 300 horses 5 or 6 died, but the great majority got well; and the second occurred at Bristol in 1894, where, out of 800 horses, 28 died, and only 123 were ill.

In using tares in this country, no one would supply to horses more than about ¼ lb. per day, mixed with from 60 to 90 lbs. of other food; but of this particular pea as much as 4 to 5 lbs. were used per day, or as much as they would have used of English beans. It is very peculiar that the parts of the body in a man mostly affected by eating this pea should be the lower extremities, while it is the laryngeal or top of the windpipe that is most affected in horses.

There is no doubt whatever that *Lathyrus sativus* is poisonous to most animals if used in large quantities of 4 to 6 lbs. per day, but it is not injurious if used in quantities of ½ lb. per day mixed with other foods. An enormous danger may occur if manufacturers crush this pea into meal and mix it with other feeding stuffs, such as meal and cakes, for cattle and sheep, and if corn merchants crush and mix it with other horse-corn, this might even be done in ignorance and without any evil intention, but the results would be very serious to horse and stock owners.

There were several discrepancies in Mr. Meachem's paper which he might be able to explain. Thus, in the last clause of his paper, he says, "it is very doubtful if a horse once affected ever regains health;"* again, in the third clause on the same page, it is stated that "35 became ill . . . and 14 recovered." Further, he states that "all the deaths have occurred to horses working in the mine; those working on the surface are all well, although fed on exactly the same diet."† He (Mr. Hunting) would like Mr. Meachem to confirm this statement, as at most of the collieries with which he was connected the food for the horses working on the surface is mixed separately from that sent into the pit, and if so the *Lathyrus sativus* might have been accidentally left out of the food sent to the surface-animals at Hamstead colliery. All the evidence in the hands of the members was against the statement made by Mr. Meachem that the horses would not recover. Only 28 of the horses at Bristol died out of 800.

Prof. W. WILLIAMS (New Veterinary College, Edinburgh) wrote with regard to Mr. Hunting's statement that he "did not use more than ½ lb. of *Lathyrus sativus* per head per day, about the same proportion as he would use of English or Dutch tares, as they were very astringent." A ½ lb. per day was, in his (Prof. Williams) opinion, a very small one and scarcely worth the trouble of mixing with other food, and if the mixing be not carefully performed there was every possibility that one horse might consume a great deal more than another; and if it be remembered that 2 lbs. per day continued for six weeks will induce the disease, it must be acknowledged that to use them at all is to create a risk of causing the disease at some time or another. If, however, it be considered true economy to save a few pounds sterling—and he did not know the difference in the value of a quarter of these vetchlings, not peas, and a quarter of oats—it cannot be much. Of course he had nothing further to say, but simply to point out that when given in the reasonable quantity of 2 lbs. per day to a horse, disease—often suddenly fatal, and seldom curable—is thus induced. Of course he (Prof. Williams) only spoke of the two kinds which had come under his immediate observation, namely, the small dark coloured seed *khesari pulse*, *latri*, *matar* or Indian *mutters*, sent here as ballast from India; and the larger white variety, the dog-tooth vetch *Lathyrus sativus*, *weisse*, called Russian peas by some dealers, sent here from the Baltic ports. Both of these kinds are equally poisonous; certainly very nutritious, and according to our

* *Trans. Fed. Inst.*, vol. x., page 186. † *Ibid.*, page 184.

present experience rendered innocuous by boiling into a pulp. The poisonous principle, supposed to be a volatile alkaloid, is driven off by boiling, and rendered harmless to the human being by being made into thin well-baked cakes.

Mr. F. G. MEACHEM, replying to the discussion, wrote that the benefit derived from using *Lathyrus sativus* as food for horses is, to say the least, a very doubtful one. In point of economy, the small quantity which Mr. Hunting says it is safe to use, effects no saving in the cost of food, and when the great risk is considered it resolves itself into playing with very dangerous material. The fact of its being used with safety in the feeding of cattle is no criterion, for cattle are not worked as horses are; quick fattening is the result aimed at in their case, but with a horse it is good work and length of service. A dealer in food-stuffs ground some foreign peas containing *Lathyrus sativus* for sale, but being informed by the writer of the dangerous nature of the vetch, he at once ceased to sell it, his trade for this meal at once fell off, and his customers asked specially for the food that he had previously supplied to them. The object of his (Mr. Meachem's) paper was to point out the dangerous nature of the vetch in imported foods which may be given unwittingly to horses. In the Hamstead case it was not known that the vetch *(Lathyrus sativus)* was present, and if it had, it would not have been suspected as poisonous. The sequel having proved it to be deleterious, he (Mr. Meachem) thought it desirable to issue a note of warning to users. He thought it lay with Mr. Hunting to show that some substantial advantages followed from the use of *Lathyrus sativus*, viz., more work and better health in the horses so fed, as compared with horses who are not fed upon it. He contended that Mr. Hunting could not prove any advantage; and while he admitted that the risk was great he did not refer to any commensurate advantages.

He would also direct the attention of members to a case tried at the Worcester assizes (Green *versus* Eagles)* in which it was shown that this vetch was in the food, causing injury to cattle; and the plaintiff was awarded £125 10s. A well-known farmer in the Birmingham district, owing to the high price of hay and corn throughout the previous dry summer, was induced to try foreign peas as food; his horses were forced to eat it and after a time they fell ill, and the animals died, the symptoms being similar to what the writer had described in the case of the horses at Hamstead colliery. Recently a similar case had been decided against a corn merchant who had supplied food containing this vetch.

* *Times*, February 16th, 1895, page 4, column 2.

With regard to the alleged discrepancies in his (Mr. Meachem's) paper, he simply stated his personal experience, to which he still adhered in the last clause; and for that in the third clause, he must refer Mr. Hunting to the *Veterinary Journal* of January, 1895.

With regard to the quantity of this vetch (*Lathyrus sativus*) used in the horse-food at Hamstead colliery, he thought it contained about 10 per cent. In conclusion, he maintained that all cases coming under his notice showed that :—

(1) There are several varieties of the vetch, some more virulent than others in their effect ;
(2) The poison is cumulative ;
(3) Horses do not afterward regain health ; and
(4) There is no economy in the use of *Lathyrus sativus* in the feeding of horses.

Mr. J. H. MERIVALE said that Mr. Hunting had explained in a very satisfactory way how the horses in a Northumberland colliery were poisoned, viz., that if a large percentage of strange food were given it would naturally not agree. Perhaps Mr. Meachem would tell them the proportion given to the horses in the case described in his paper. Had Mr. Hunting any experience in using moss-litter in colliery stables ?

Mr. HUNTING said that he used moss-litter for at least 6,000 colliery horses and ponies. About twenty or thirty years ago, the effluvia met with on going into underground stables was very objectionable, whereas, now they could go into a stable and scarcely know that it was a stable until they saw the horses. Moss-litter was an excellent absorber of urine, and if the colliery worked a farm, the salts of the urine from 400 to 500 horses would be very valuable, and would fully repay the cost of the moss-litter. It was also invaluable for saving the horses from knocks and bruises, and as straw was not allowed for bedding in mines, he did not know where they would find anything so advantageous as moss-litter. There was not a single objection to its use, either as affecting the horses' feet, or with reference to the spread of infectious diseases, such as influenza. He was only aware of one colliery where straw was allowed for bedding the horses in underground stables, owing to the risk of fire.

He ought, perhaps, to explain that moss-litter is not used in all the stalls underground in all pits, but only in the worst stalls where stagnant urine is seen; but it is used in every loose box, 2 to 4 inches thick, with marked advantage, in preventing injury to the eyes and heads, when horses are very violent in spasmodic colic, and especially in preventing ruptured

stomach, mid-riff, or large intestine, often produced by the animal throwing himself violently on the bare ground in acute cases of colic. In such cases it is invaluable in saving the life of the animal, because eight out of every ten cases of rupture of the abdominal organs are produced by violent concussion on the ground, or by falling on a rail or prop on the ground. This simple preventive is of much more importance than appears at first sight; thus in looking back for twenty years into "case-books" of over 1,000 pit animals he found that now only 1 per cent. of colic cases were fatal; whereas in 1850 to 1860 more than 30 per cent. were fatal. No doubt, improved systems of feeding have much to do with preventing colic, but he was not speaking of the number of cases but of the percentage of fatal cases, now and then. The fatal cases are now only as 1 to 30; but the number of cases now are as only 1 to 300 in 1850 to 1860.

Mr. JOHN JAMESON read the following paper on "Recovery of Bye-products in the Manufacture of Hard Coke":—

RECOVERY OF BYE-PRODUCTS IN THE MANUFACTURE OF HARD COKE.

By JOHN JAMESON.

The writer having been invited by the Council to be present at the reading of, and to take part in the discussion on, two papers on the recovery of bye-products produced in the manufacture of coke in close coke-ovens, thought it right to decline on the ground of incompetence to afford any useful information on processes as to which he had no personal experience and only imperfect information. He, however, offered instead, if it would be acceptable, to contribute a paper on his own process of recovery of bye-products in open coke-ovens, as to which he had a very costly experience and information acquired in circumstances of deep personal interest. He may remark, as a fact preliminary to the other facts which he proposes to lay before the members, that he has now no pecuniary interest whatever in the process he is to describe, and no hope of furthering the interests of others who were associated with him in it. The company which was formed to work the patents is in liquidation, and the patents have lapsed. The writer believes, however, that this method of recovery of bye-products in open ovens, unless displaced by some more effectual one, will certainly, in the course of time, come into extensive use.

The writer began business in a chemical works in London, where a process very similar to that now so successfully carried on by Messrs. Brunner, Mond, & Co. was in operation. The ammonia-liquor of gas-works was distilled to increase its strength, the distillate was mixed with salt, carbonic acid was supplied from a covered lime-kiln, and in that way about 4 tons of alkali was manufactured per week (test 48), and about 3½ tons of muriate of ammonia. The difficulty at the time, however, was to obtain a sufficient supply of gas-water, and to work the process as a secret.

That ammonia-soda process (as is well known) was a modification of one previously worked by Messrs. Dyer & Hemming. But as that original process involved the recovery of the caustic ammonia (as the Solvay process does) and the supply of any loss of that extremely volatile

material from costly ammoniacal salts, Messrs. Dyer & Hemming's manufacturing operations were abandoned, after very large sums had been spent upon it. It is now improved into the process used by Messrs. Brunner, Mond, & Co.

In the difficulty as to supply of ammonia, the writer thought of the possibility of obtaining a supply by suction during the process of coke-making, and made a successful experiment with a small coke-oven built for the purpose and holding about 1 ton of coal. Circumstances, however, which have no interest in this history, prevented any further result at the time, and the idea of recovery from coke-ovens in the way subsequently patented by the writer remained in abeyance.

About fourteen years ago, however, the idea was experimented upon at the Felling chemical works, where there were some coke-ovens available. Exceedingly good, and even surprising results were obtained, and the invention being patented, and the results made known, coals were sent from all parts of the country to Felling to be tried for yield, and many very remarkable recoveries of products were obtained in over 200 different experiments. Many of the people who sent specimens of coal sent their representatives to watch the process in operation, and personally to verify the results.

After a little time the process was adopted by some of the most important firms in the kingdom, amongst whom may be mentioned Messrs. Bell Brothers, the Weardale Iron and Coal Co., and Messrs. John Brown & Co., of Sheffield, and in regard to the experience of the two first-named, the author may mention that after the conversion of ten coke-ovens, and working them for some time, these firms were so satisfied with the results obtained in their own experience at their own works, that they each made a further conversion of twenty more coke-ovens, and at the Weardale Iron Co.'s works adapted the suction and condensing-plant for 150 ovens. The recovery of products was even greater than the recovery from the same coal at Felling. The quantity of coke produced was found to be in no way diminished, and the percentage of residual sulphur was reduced.

Sir Lowthian Bell made experiments on the quality of the coke, to see if any injury had been done to it for metallurgic purposes by the extraction of the products, and he found by continuous trials of this coke (by itself alone) in the blast-furnace, that it was in every respect fully equal to coke made in the ordinary way without any recovery of products.

So far as the appearance of the coke went, the writer may mention that one large manufacturer of high class coke wished to have the opinion of an expert on that point, as to the manufacture at the Weardale Iron

Co.'s coke-ovens, and in order to free his opinion from prejudice, the writer arranged beforehand that the coke from the converted oven should be placed opposite an ordinary oven, drawn on the same day, and that the coke of that ordinary oven should be placed in front of the converted oven. And being misled by this modified position, the expert gave his decided opinion that what he thought was the Jameson coke was not equal to what was really Jameson coke. And having had the heaps turned over, he pointed to numerous specimens showing the inferiority he complained of. The writer believes that unconscious prejudice produced the unfavourable opinion which he expressed, and that really there was no discoverable difference.

The writer read a paper before the members of the Iron and Steel Institute at Middlesborough,* giving some particulars of the results obtained at the Felling chemical works, estimated to average in different varieties of coal, 8 gallons of oil, ammonia equivalent to 10 lbs. of sulphate, and 12,000 cubic feet of burning gas per ton of coal coked, and he quoted also the results obtained by the Weardale Iron Co., and by Messrs. Bell Brothers. In a little time after that meeting, the writer was informed that it was the intention of Messrs. Bell Brothers to convert another 100 coke-ovens, that the partners thought the paper referred to had not done full justice to the process, and that they proposed, at a later time, to supplement the author's paper by a paper on their own experience of it.

It will be observed that all that the author has so far written is in direct commendation of the Jameson process. He has now to turn in its history to the period of its apparently signal failure.

After a lengthened time of continuous working with ovens as at first converted, it was found that the gas became explosive, and at a later time it became unburnable, and the yield of bye-products fell off by degrees in corresponding proportion. At the first installation of 10 coke-ovens at the Weardale Iron Co.'s works, the gas extracted used to be burned continuously at the top of a stand-pipe (as had been done at Felling under the boiler), and while obtaining a regular yield of 4 to 5 gallons of oil per ton of coal, continuous sparkles of oil could be seen, in bright daylight, in the blue flame of the gas, indicating that by more perfect scrubbing arrangements a still larger yield might have been obtained. The suction applied was equivalent to from 2 to 3 inches of water, but it was sometimes run at a higher suction, and the working was practically uniform and continuous for several months. The author admits that he, and those

* *Proceedings*, 1883, vol. ii., page 504.

associated with him, ought not to have been unable to account for the change he has described, but for some length of time what he believes to be the true cause was not thought of. And very many experiments of different kinds were tried without any beneficial result.

The coke-ovens were originally converted by building in the inside a pan of brickwork below the floor, the bricks being set in a mixture of fire-clay and tar, making a kind of asphalte, which when fresh laid was practically quite impervious to air. We found afterwards that this was a serious mistake. After a few months of working the heat of the ovens so dried up the tar as to make the pans which had at first been nearly air-tight, quite loose and porous, and entirely altered the conditions. While the pan was air-tight, the gas withdrawn from the coke-oven came from the charge of coal in the oven, and it was a good burning but not illuminating gas. When the pan became more and more pervious to air, so much air was drawn in as to make the gas explosive. When the process of disintegration of the materials of the pan had gone further, a larger dilution of the gas made it non-explosive and unburnable. The suction took, of course, what came to it most easily.

In the experiments at Felling, in order to ascertain what was being drawn from a coke-oven, a large gas-meter was fixed between the exhauster and the oven, and with 3 or 4 inches of suction when the process was working the extraction was about 1,000 cubic feet of gas per hour, equal to about 12,000 cubic feet of gas per ton of coal coked.

Some considerable time after the yield of products at the Weardale Iron Co.'s works had fallen off as the writer has described, an apparatus was constructed to indicate the quantity of gas passing in the main pipe from twenty ovens, and it was found that with less than one quarter of the suction which had been at first applied, the passage of gas was 6,000 cubic feet per oven per hour, or 70,000 cubic feet per ton of coal coked. The writer thinks it is correct to assume that, as the yield of oil fell to one quarter of what it had been originally, the actual gas taken from the oven was reduced to about a quarter of what it once had been ; and, if so, the gas extracted would consist of 1 part of coal-gas and about 24 parts of air, a mixture inexplosive and unburnable. In carefully opening the floors of ovens he found little accumulations of dust with hollow centres all over the bottom of the pan in shape like miniature volcanoes, which were no doubt in active operation, giving currents of air when the suction was on.

This process of decay in the efficiency of the pan (which it was intended should be air-tight), the author and his co-workers were some

considerable time in discovering. It had not caused trouble at Felli no doubt for the reason that there the coke-ovens were frequently cool Many experiments were made from time to time in the Felling co ovens with different forms of false-bottom, and different areas of p and at every change the coke-oven operated upon was cooled off, pan-bottom exposed and often relaid in a new form; and thus the def arising from continuous working was most unfortunately undiscover When the discovery was actually made, the composition of the pan changed. Many varieties of cements were used, asbestos paper, silic of soda, and various other materials, and it was found invariably t with a newly constructed oven-bottom one got good burning gas, was able to carry a high suction, and in yield of products one obtai the same results as at Felling. But each of these experiments too very long time, because the question with each was whether the efficie of the pan would continue for such a length of time as to make renewal comparatively an unimportant item of expense.

The author need not enter into any details of these experime because at a later time the whole were superseded. An iron pan was us made in sections so as to pass through the door of the coke-oven, and w internal angle-irons by which it could be bolted together. This pan filled with water up to the height of the suction-pipe, and standing in pan, partially immersed in the water, were the iron supports of the fal bottom. The pan was, of course, perfectly air-tight. The quicker r of conduction in the iron, and the slower rate of conduction of the fi brick false-bottom, and the near presence of the water to every part, k it from the least distortion of shape, and from any injurious action the fire. Thus the only iron pan made was worked continuously fo year, and found to be practically uninjured in any way, and entir efficient at the end of that time. In fact, the writer believes that t was a perfect solution of all the difficulties of the process, and had t started with it at first the process would have been by now, he belie adopted almost universally.

The question will naturally arise (having arrived as was suppo at a satisfactory solution of the problem which had troubled us so many years), why we did not prosecute the enterprise with energy, a at once seek to recover our lost ground? The author believes that answer must be found in the fact that we were a limited liability comp —our actions were the actions of a company, and not of an individual.

Mr. WILLIAM COCHRANE said that they were indebted to Mr. Jameson for having brought before them an account of failures in the recovery of bye-products, for very often they learned more from failures than from successes, but if they had been so near success as these experiments seemed to lead them to believe it was a pity that his process had not had further trial. He asked whether the Jameson process was in use anywhere at the present time? He had given it a trial himself some years ago but was compelled to abandon it. He would like to know whether the amount of water in the coke did not seriously affect its quality?

Mr. A. L. STEAVENSON said that Messrs. Bell Brothers had tried the ovens for a long time at Page Bank colliery. He was of opinion that the process might be worked successfully if a gentleman of ability and chemical knowledge had charge of the arrangements, and could attend to the ovens, but the process was not successful under the charge of an ordinary foreman. He had never observed any difference in the quality of the coke; it always appeared as good as from the ordinary oven, but the oil, so far as he could judge, was rather poor in quality.

Prof. P. PHILLIPS BEDSON said that the paper explained why the method which made such promise fourteen years ago, in giving a coke which would satisfy the requirements of the ironmaster, and which partially obtained success in the recovery of the bye-products, had not been successful. With reference to the oil, he thought an examination showed that the hydrocarbons contained in the oil obtained from the Jameson coke-oven were different from those contained in the oil obtained in the manufacture of coal-gas, and from those obtained by the Simon-Carvès and other similar retort-ovens. The great difference was in the proportion of benzene, and this was serious, as it was the most valuable hydrocarbon obtained from coal in the manufacture of coal-gas.

Mr. JAMESON, replying, said that there were no coke-ovens of the Jameson type at present in use. It was perfectly correct that the oil was not of the same character as that produced in gas-works, as the tar-product belonged to the paraffin series instead of the benzoline series. He thought that the proportion of water left in the coke was not greater than in the ordinary process.

Mr. W. C. BLACKETT asked what was the difference between the Jameson process and that adopted by Messrs. Newton and Chambers, where air-pressure was put upon the coke-oven, the gaseous products

being driven through the oven-bottom, and he believed that they were working very successfully in the recovery of bye-products, including Izal, a new disinfectant ?

Mr. JAMESON said he did not think that there was much difference between the process described by Mr. Blackett and his own. In the Aitken coke-oven pressure was put on the oven, but there was no suction on the bottom of the oven.

Mr. WILLIAM COCHRANE asked whether the latest improvement in the Jameson process would enrich the oil ?

Mr. JAMESON replied that the oil would not be enriched.

Mr. A. L. STEAVENSON proposed a vote of thanks to Mr. Jameson for his interesting notes, and suggested that Mr. Cochrane or some other gentleman who had coke-ovens should be induced to make a further trial of the Jameson process, and possibly prove its success.

The vote of thanks was cordially adopted.

The following paper by Mr. Winkhaus on "Safety Explosives" was read :—

SAFETY-EXPLOSIVES.*

By BERGASSESSOR WINKHAUS.

It is generally known that the experiments with various explosives, conducted by the Prussian Fire-damp Commission in the experimental gallery at Neunkirchen, led to the result—that high explosives, such as nitro-glycerine, gun-cotton, and blasting gelatine, if a sufficiently strong detonator be used, will detonate perfectly without igniting either coal-dust or pit-gas.† This was deemed an all-sufficient ground for the assertion that one may proceed unhesitatingly to fire shots, provided a preliminary examination with a safety-lamp has shown that not more than 3 or 4 per cent. of pit-gas is present in the surrounding atmosphere. If the percentage of gas be higher, ignition by electricty is recommended. It is further asserted that gelatine-dynamit I., mixed with 35 per cent. of powder, may be regarded as perfectly safe in atmospheres containing from 8 to 10 per cent. of pit-gas; while, on the other hand, the safety of guhr-dynamit is diminished by the admixture of a neutral powder (kieselguhr), in such wise that atmospheres containing 4½ per cent. of pit-gas become dangerous, and are so even with a smaller percentage of gas—if there be much dust in suspension.

The results of these investigations gave rise, at a meeting of the Prussian Fire-damp Commission on June 25th, 1885, to a very lively exchange of views.‡ Two opposite camps joined issue—the one wishing purely and simply to forbid shot-firing with ordinary blasting-powder in fiery mines, but permitting the use of dynamite under certain circumstances—namely, when in a particular district of a mine the safety-lamp shows that no fire-damp is present; the other not allowing even dynamite to be used, at least in the coal. The partizans of the first view rested their case on the above summarized results, while those of the second appealed to a number of instances wherein shots fired by dynamite had actually ignited gaseous mixtures. Nevertheless, at the meeting of June

* Translated by L. L. Belinfante, B.Sc.

†*Haupt-Bericht der preussischen Schlagwetter-Kommission* (Report of the Prussian Fire-damp Commission), *Supplement*, vol iv., page 77.

‡ *Ibid.*, *Supplement*, vol. i., page 63 *et seq.*

26th, 1885, Article 19 of the "Principles Determining the Working Fiery Mines" was adopted by a large majority in the following terms :-

In all fiery mines, shot-firing with blasting-powder and similar slowly explodi substances is forbidden. The use of dynamite, and substances which resemble it their behaviour as regards coal-dust, and in rapidity of explosion, is alone p missible.

Even with dynamite and its congeners, shot-firing is to be prohibited in th pits, where at any point in the workings under normal conditions, it is fou impossible to avoid such accumulations of fire-damp as are easily recognizable w the safety-lamp. (This implies about 3 per cent. of gas.)

But the experiments made by Mr. Lohmann, in the experimen gallery at Neunkirchen, soon showed that the harmlessness of gelatin dynamit and its associates was by no means so well assured as the fi series of experiments of the Prussian Fire-damp Commission had led o to believe. Two reports embodying the results of the further experimen were published in 1887, in which guhr-dynamit, gelatine-dynam blasting-gelatine, and gun-cotton are uniformly described as eith dangerous or highly dangerous in presence of fire-damp or coal-dust. M Lohmann arrives, indeed, at the conclusion that

The use of high explosives in the presence of fire-damp, and particularly working-faces where there is dry coal-dust is, in all probability, infinitely m dangerous than one has hitherto been inclined to admit, and further, that t prohibition merely of ordinary blasting-powder and its congeners, with a view the avoidance of fire-damp and coal-dust explosions, would be of so little effect to be hardly worth mentioning.*

Results so startlingly diverse from those arrived at by the investigato of the Prussian Fire-damp Commission naturally lead us to enquire when such differences can possibly arise. If we consult carefully the *Report* we shall note that, in the experiments conducted by the Prussian Fir damp Commission, in each case only one cartridge was used, left lying fr on wooden blocks, sometimes sprinkled with coal-dust, or else suspende in mid-air. It was only when Mr. Lohmann proceeded to make tria with large quantities of explosive that the ignition of pure coal-du atmospheres regularly took place with the so-called high explosives, and was through Mr. Lohmann's investigations, first of all, that the former universally accredited opinion as to the parallel ratio of increase of bla ing-power and of safety (in regard to fire-damp and coal-dust) of su explosives was rudely dispelled. Moreover, his experiments stimula inventors to work for the improvement of explosives in the direction safety, and it is from that time that we may date the first appearanc

* "Results of the investigations conducted in the experimental gallery a König pit, Neunkirchen, etc.," by Mr. H. Lohmann. *Zeitschrift für Berg-Hü und Salinenwesen*, vol. xxxv., pages 271 *et seq.*, 352 *et seq.*

the so-called flameless or safety-explosives. All those mining districts, where the battle against fire-damp and coal-dust has to be fought, have since then taken up actively the question of safety-explosives, and it is no exaggeration to affirm that at the present day that question has made a vast stride in the direction of progress.

The writer's remarks will therefore be devoted to a more detailed consideration of the subject as it now shapes itself in Westphalia, on the basis of the investigations carried out in the experimental gallery of the Westphalian Miners' Provident Society.

The ways and means whereby the manufacturers of explosives sought to render their products less and less dangerous in the presence of fire-damp and coal-dust were all directed to the one end of reducing as much as possible the temperature of the gases evolved on explosion, that is, the so-called temperature of detonation. It was sought to effect this in one way by mixing high explosives, such as dynamite, with substances containing water in mechanical or chemical combination and with easily vaporizing substances, whose vaporization and decomposition was intended to capture a part at least of the heat evolved on explosion. Among the substances thus used were damp sawdust, soda-crystals, sulphate of magnesium, carbonate of ammonium, etc., and these mixed in various proportions with kieselguhr constituted the so-called wetter-dynamit. To this group coal-carbonit also belongs.

Another way of reducing the temperature of the gases evolved on explosion consisted in making the explosives of such substances as of themselves have a relatively low detonating temperature. Such are the explosives belonging to the so-called sekurit group, preceded as they were by the Sprengel explosives, mixtures of nitrated hydrocarbons with nitric acid. In practice only the first-named of these are in actual use; they were invented by Dr. Schöneweg, a pharmaceutical chemist at Dudweiler, and consist in the main of intimate mixtures of nitrate of ammonium with the nitro-compounds of the aromatic hydrocarbon series, or with non-nitrated carbonaceous substances. Among these may be reckoned the multifarious explosives, so many of which have been just lately brought out, sekurit, roburit, westfalit, dahmenit, dahmenit A, progressit, rhönsalit, roburit I, and the Cologne-Rottweiler safety blasting-powder. In these explosives also the principle of admixture has been applied for the purpose of lowering the temperature of detonation. Their composition, in so far as it has been possible to ascertain it in the course of the investigations at the Westphalian Miners' Provident Society's experimental gallery, is stated in the accompanying tables (Fig. 1, Plate IX.).

Explosives of either type are known in Germany as safety-explosives, but an exact definition as to what is really a safety-explosive is still to seek.

In his latest memoirs on the behaviour of various explosives in the presence of fire-damp and coal-dust, based on investigations pursued at the Neunkirchen experimental gallery, Mr. Lohmann attempts, however, to set forth a definition of safety-explosives. He holds that all such as prove on experiment to be considerably safer than ordinary dynamite, and have not, in practical mining, produced the ignition of fire-damp and coal-dust, should be reckoned as safety-explosives;* further on, he remarks that "in any case a sufficient degree of security may be deemed to have been attained, when an unstemmed shot, fired with a charge of 8·82 ounces (250 grammes) from the steel cannon, in the experimental gallery at Neunkirchen is found incapable of igniting the coal-dust in suspension (from the König pit)." † Unfortunately, practical experience in Westphalian mines has shown that explosives, which with far higher charges appeared unable to ignite coal-dust in the experimental gallery, have on several occasions been the cause of fire-damp and coal-dust explosions in the mine. We must therefore conclude that the above-defined degree of security is not sufficiently certain to completely eliminate the risk of an explosion below bank.

In France, however, they have been able to approach more nearly an exact determination by laying down regulations as to the properties which must characterize any explosive intended for use in fiery or dusty mines. Basing himself on the investigations carried out by Mr. Mallard, the French Minister of Public Works, under date August 1st, 1890,‡ issued a decree prescribing that in dangerous mines only such explosives should be used in the working of stone as yield a temperature of detonation not exceeding 1,900 degs. C. (4,060 degs. Fahr.), and if in coal itself, the temperature of detonation should not exceed 1,500 degs. C. (3,212 degs. Fahr.). In accordance with the statements set forth in an appendix,§ this temperature must be calculated from the various constituents which go to make up the explosive; and, in order to make that calculation possible, the explosive must be enclosed in a cartridge which bears on its cover an indication of the character and quantity of the said constituents.

* *Glückauf*, 1893, vol. xxix., page 1,177.

† *Ibid.*, 1893, vol. xxix., page 1,435.

‡ *Report of the French Commission on the Use of Explosives, etc.* Translated by Messrs. Bird and Walton Brown, page 162. § *Ibid*, page 163.

How far the theoretical values thus obtained are applicable to the values aimed at in the investigations conducted in the experimental gallery is a point to which the writer will have the opportunity of recurring later on. We may, at all events, remark in passing that the standard of security defined by Mr. Lohmann is much below that theoretically determined by the French authorities.

Personally, the writer does not consider it possible to express numerically such a standard of safety for an explosive as will imply its absolute harmlessness in all and every circumstance, and he fails, moreover, to see that such is needed. The very latest improvements in the technique of safety-explosives are, as it so happens, thrusting this standardizing question more and more into the background. We can nowadays avail ourselves of explosives which fulfil extremely exacting conditions in regard to safety, and which at the same time fulfil all requirements in the matter of blasting effect and explosive power, and there is every reason to believe that further progress will be made in this direction. It is then merely a question of time: sooner or later, in all fiery and dusty mines, only such safety-explosives will be used as will be shown, by the results obtained in the various experimental galleries, to possess an unquestionably high degree of safety.

The arrangements for these researches, which are now customary in all fiery and dusty mining districts, have been modelled on those made for the experimental gallery at the Government colliery of Neunkirchen, the oldest in date, set up by the Prussian Fire-damp Commission. This has served as a pattern even for the newest of all, the experimental gallery built by the Westphalian Miners' Provident Society at the Consolidation pit, near Gelsenkirchen.

It is hardly necessary to describe here in detail the manner in which these galleries are fitted up, as the writer takes it for granted that this is now well known. He will merely point out that the main difference between the Saarbrücken and the Westphalian experimental galleries consists in their various dimensions. That now in use at Saarbrücken has a length of 39·37 feet, and an elliptical cross-section of 4·43 by 3·77 feet, while the Westphalian gallery is 115 feet long, and has an elliptical cross-section 6·07 feet high by 4·43 feet broad.* The larger cross-section was resolved upon, on the one hand, in order to approximate more closely to the conditions obtaining in Westphalian mines, and on the other in order to facilitate working in the gallery. The greater length was intended to enable simultaneous investigation to be made of various coal-dusts, as to their more or less dangerous character.

* *Trans. Fed. Inst.*, vol. ix., page 250.

The main principle which invariably presided at the construction of such galleries was never to diverge needlessly from the conditions actually obtaining in the mine. So far as the interior of the galleries is concerned, we may consider that this principle has been successfully maintained. Moreover, the manner of deposition and suspension of the coal-dust underground, and the accumulations of fire-damp met with in the mine are closely imitated in an experimental gallery. But those conditions which cannot be reproduced, and yet which are the most vital of all, are the circumstances following on the firing of a shot at the coal-face. One has here to make shift with a cannon or mortar, provided with a bore-hole, and made as strongly resisting as possible, whence the shots are fired. This, however, does not in the remotest degree correspond to actual shot-firing in coal. The differences are many: in a bore-hole in coal the walls, being of coal, consist of a material which is a very bad conductor of heat, and consequently when a shot is successfully fired, the entirety of the heat produced by the gases resulting on explosion is available for igniting inflammable atmospheres if circumstances are otherwise favourable. In a cannon, on the other hand, the walls being of cast steel and good conductors of heat, a portion of the heat of detonation is held captive. Within a bore-hole in coal, a quantity of extremely fine dust is formed on the firing of a shot. Moreover, in the case of fiery seams, there is always a flow of fire-damp into a long bore-hole, and when the stemming has been rammed in, the gas fills up all hollow spaces between the cartridge and the walls of the bore-hole, and thus an additional danger is created which cannot be imitated in the bore of a cast-steel cannon.

But if divergences, which are of this importance, and cannot be got rid of, exist between the conditions prevalent in the mine and the conditions obtainable in an experimental gallery, it follows plainly that no direct, irrefragable conclusions can be drawn from such experiments for application in everyday practice. More particularly is it undesirable, on the faith of investigations conducted in an experimental gallery, to fix the safety limit as to quantities of explosives allowable underground. This will be the more readily conceded as, in point of fact, in different galleries or drifts (the conditions being the same in all) for some hitherto unexplained reasons extremely diverse results have been attained.

The aim, therefore, of such experimental investigations must be restricted to a comparison of the relative safety of various explosives. If the values obtained are made use of in practical work, they must be revised in accordance with the results of actual experience in the mine.

For this reason alone the writer is of opinion that it is of extreme importance, in all cases where a fire-damp or coal-dust explosion has occurred underground, following on the use of so-called safety-explosives, to make a most careful and minute investigation as to the quantity used and the properties of the explosive, and in particular to ascertain whether it is really the safety-explosive that has determined ignition, and whether the simultaneous (and surreptitious) use of a dangerous explosive, such as dynamite, was under the circumstances absolutely impossible. In Westphalia, cases of the kind herein alluded to have occurred. But it is only by diligent enquiries of this nature that we shall obtain data which will justify the practical application of the results obtained in experimental galleries.

In making experimental investigations we need not then be so much concerned as to the exact nature of the conditions assigned for the experiments, but concentrate our attention on making these conditions in all cases identical. Still, the writer may point out that the conditions presupposing the greatest amount of danger are the best suited for experimental enquiry. Consequently in the experiments now under consideration every shot was fired without stemming from the bore (18·11 inches long and 2·16 inches in diameter) of a crucible-steel cannon or mortar. This was so built into the floor of the gallery that the axis of the bore (which protruded about 10 inches) being prolonged vertically would meet the roof at a distance of 33 feet. The charge was placed at the end of the bore-hole.

For the purpose of ensuring that the conditions regarding coal-dust were identical for every shot fired, each time, whether there had been ignition of coal-dust or not, fresh dust was strewed along the floor in just the same quantity as before for a length of about 16 feet from the working-face, and dust was also whirled about in the atmosphere of the gallery by means of the fan fitted to the roof. The character of the dust was continually investigated by repeated analyses: these showed very slight variation in chemical composition, and as the dust was always obtained from the same source its physical properties also exhibited very little variation. For experiments with fire-damp mixtures an explosion-chamber of about 353 feet cubical content was used: this was arranged by setting up a paper partition about 17 feet distant from the working-face. The composition of the gaseous mixtures was determined by drawing off and analysing samples on each occasion. In the case of experiments conducted in the presence both of coal-dust and fire-damp the dust was strewed on the floor before the introduction of the gases, but the whirling

of dust in the atmosphere was done afterwards, very shortly before firing the shot.* Every explosive tested was subjected in increasing quantities, until ignition ensued, in the following experiments. (It was previously settled that the quantity sufficient to produce ignition should be limited to 18 or 21 ounces) :—

1.—In presence of coal-dust without fire-damp.

2.—In presence of coal-dust and a gaseous mixture just recognizable with the safety-lamp (that is, about 2½ per cent.).

3.—In presence of explosive mixtures of 6 to 7 per cent. fire-damp and coal-dust.

4.—In presence of explosive mixtures of 6 to 7 per cent. fire-damp without coal-dust.

With the single exception of blasting-powder all the explosives used in Westphalia were included in the series of experiments.

The results are graphically represented in Fig. 1, Plate IX. In the first column is the name of the explosive, and in the second its chemical analysis by Dr. Broockmann, of Bochum, while in the other columns are set forth the behaviour of each explosive under the above-mentioned conditions. The lengths of the rectangles in the respective columns represent the charges: the shaded rectangles indicate what weight of the particular explosive gave rise to ignition under the conditions set forth at the head of the table. If the rectangle is left blank, this implies that the quantity of explosive thus symbolized was used, but did not give rise to ignition. The accompanying numerals indicate what weight was used on each occasion. The figures in the last column represent the comparative expansions obtained in the Trauzl leaden receiver test (a charge of about 0·35 ounce being placed in the bore of a leaden cylinder), and therefore show the relative blasting efficiency of the various explosives.† Gelatine-dynamit alone is tabled as not belonging to the group of so-called safety-explosives. Guhr-dynamit, stonit, and sekurit behave in much the same way as it does.

The first thing that strikes one on looking at this table is the peculiar behaviour of those explosives, which, on account of their hygroscopic properties, are packed in coverings smeared over with paraffin. Among them are the nitrate-of-ammonium explosives, roburit, westfalit, and dahmenit. The Cologne-Rottweiler safety-blasting-powder, which belongs to the same group, is packed in tinfoil cartridges to protect it from dampness. In the case of the three former explosives, when tested in the original cartridges in a pure coal-dust atmosphere, they gave rise to ignition even with comparatively small charges, but proved safe, not to say very

* *Trans. Fed. Inst.*, vol. ix., page 253. † *Ibid.*, vol. x., page 264.

safe, if, instead of the paraffined cartridges ordinary paper-covered cartridges were used,* as may be seen in the next column. On the other hand, the nature of the original covering seemed to have no influence whatever in the case of explosives possessing a high degree of safety, as shown by a series of experiments with dahmenit A and roburit I. The first named, for instance, with a charge of 17·64 ounces in the original cartridges did not cause ignition despite the presence of 7¼ per cent. of fire-damp; but with a charge of 19·75 ounces in non-paraffined cartridges, ignition was brought about. And even with 17·64 ounces, out of fourteen trials, ignition took place in one case in presence of 7¼ per cent. of fire-damp, although the explosive was in the ordinary paper covering. Whence we see that whether the cartridges were paraffined or non-paraffined, the degree of safety was precisely the same. A similar series of experiences is recorded with roburit I, which gave rise to no ignition whatever, with either paraffined or non-paraffined cartridges.

This curious phenomenon is alone explicable by the intervention of the temperature of detonation. If the temperature resulting on explosion is sufficiently high to vaporize and ignite the paraffin, then the influence of that substance comes in; it is ignited itself, and in turn ignites the coal-dust. But if the temperature on explosion proves insufficient to start the ignition of the paraffin, then we may regard the explosive as possessing so low a temperature of detonation that it is very safe, even in the presence of large percentages of fire-damp.

Therewith the experimenter, and more especially the manufacturer of explosives, is put in possession of an invaluable datum for determining, simply by means of two or three shots, the degree of safety of an explosive, since it is only necessary to fire off a charge of about 16 ounces in a paraffined cartridge in presence of coal-dust. Unfortunately, it has not as yet been possible to bring to an end the series of experiments concerning the influence of the paraffin on stemmed shots. The writer is not, therefore, in a position to state whether the effect of paraffin is equally considerable in the case of these.

The next following columns show what occurred in the presence of coal-dust and a gaseous mixture containing only a small percentage of fire-damp. In such cases most of the explosives failed to bring about ignition. But it is important to note that even very small percentages of fire-damp do reduce very considerably the degree of safety of an explosive, as may be seen from the experiments with gelatine-dynamit, wetter-dynamit, and roburit.

* For this reason these explosives are packed in double cartridge-cases, so called "purse or sack cartridges," and the outer, paraffined casing is removed before using the explosive.

The most interesting of all, however, is the next column, wherein is tabled the behaviour of the various explosives in presence of gaseous mixtures containing 6½ to 7 per cent. of fire-damp. We see by it that newly-introduced explosives are in use in Westphalian mines, which possess a very high degree of safety (as shown by the experiments with dahmenit A, roburit I, Cologne-Rottweiler safety blasting-powder, and coal-carbonit), and at the same time have also a tolerably high shattering power (as shown by the figures in the last column).*

With the exception of coal-carbonit, these new safety-explosives all belong to the nitrate-of-ammonium group, and consist of two main constituents: nitrate of ammonium as the oxygen-supplier and any carbonaceous substance as a carbon-supplier. The point about these safety-explosives is that the heat set free by the decomposition of the nitrate of ammonium, the so-called temperature of detonation, is relatively very low, not rising theoretically above 1,129 degs. C. (2,064 degs. Fahr.). But this substance is of itself not at all easily decomposable, and has, therefore, to be mixed with carbonaceous, that is, combustible substances, in order to be of any use as an explosive. With the increase in quantity of the carbonaceous constituent the temperature developed on explosion rises, while the degree of safety is correspondingly lowered.

In order to test this assertion the writer has caused an explosive of the sekurit group, consisting of dinitro-benzol and nitrate of ammonium, to be made up in variously proportioned mixtures, and he has made experiments therewith. Fig. 2 (Plate IX.) illustrates the results thus obtained.

In the first column, the composition of the explosive is graphically represented, the lighter shade indicating the carbonaceous constituent, and the darker shade the oxygen-constituent. Five different proportions have been selected, as follows:—

Nitrate of Ammonium. Per Cent.	Carbon Supplier. Per Cent.	Containing of Carbon. Per Cent.
83	17	7·29
86	14	6·00
89	11	4·72
92	8	3·43
95·25	4·75	2·04

The results show in the most unmistakable fashion that the safety of the explosive is considerably diminished when the proportion of carbon is increased, and this fact is confirmed again and again under all the various conditions with which the explosive was tested.

* As no difference was observable in the results obtained with fire-damp mixtures when coal-dust was present and when it was absent, only one series of experiments has been included in the table.

The values obtained furnish us with the necessary data for comparison with the theory, as to the height of temperature of detonation in the case of a safety-explosive, propounded by the French authorities. Moreover, the proportional compositions selected are such that the numerical expressions needed for these calculations, namely the heat of formation of the constituent parts, become known. It was in this way that the values tabled in the fifth column were calculated. According to Mr. Mallard's theory, an explosive whose temperature of detonation is 2,200 degs. C. (3,992 degs. Fahr.) in charges of rather less than 2 ounces would ignite fire-damp mixtures. Now, the theory is in fact confirmed by the experiments, since precisely that charge of 17 per cent. sekurit, whose temperature of detonation is 2,200 degs. C. (3,992 degs. Fahr.), did cause a fire-lamp mixture to explode. With 8 per cent. sekurit the temperature of detonation is reckoned as 1,696 degs. C. (3,084 degs. Fahr.), and the charge had to be increased to 12·35 ounces before ignition of the fire-lamp mixture was produced. While in the presence of coal-dust without fire-damp, and using non-paraffined cartridges, even a charge of 17·64 ounces failed to produce ignition. As the French authorities have decreed that explosives permissible in coal-workings shall possess a temperature of detonation not exceeding 1,500 degs. C. (2,732 degs. Fahr.), the statement made at an earlier page, to the effect that Mr. Lohmann's standard limit for a safety-explosive is far inferior to the French standard may be regarded as fully justified.

What degree of safety an explosive must possess in order to conform to the French standard, according to the experiments made in the Schalke gallery, may be gauged from the last proportional mixture used, which had a temperature of detonation reckoned as 1,482 degs. C. (2,699 degs. Fahr.) With the original paraffined cartridges in charges of 14·11 ounces (400 grammes) no ignition of coal-dust was produced, but in presence of 7 per cent. of fire-damp charges varying from 17 to 20 ounces (500 to 550 grammes) did produce ignition. Whence we may conclude that the new safety-explosives dahmenit A, Cologne-Rottweiler safety blasting-powder, roburit I, and also coal-carbonit fulfil the conditions laid down by the French authorities. We cannot, however, calculate the temperature of detonation of these explosives by means of Mr. Mallard's formula, because we are ignorant of the heat of formation of their constituents.

The example just cited furnishes, moreover, adequate ground for the conclusion that it is possible to give exactly what degree of security one chooses to any safety-explosive ; two factors must nevertheless be regarded as limiting the scope of this conclusion :—(1) The detonating capacity or

degree of facility of transmission of the explosion from cartridge to cartridge ; and (2) the blasting efficiency of an explosive.

With regard to the first point, the writer would mention that only by means of a special manipulation of the explosive was the manufacturer enabled to cause it to detonate (when least rich in carbonaceous constituents) with the ordinary detonator, a circumstance which precluded its manufacture on the large scale. Anyone who has worked underground with safety-explosives of the nitrate-of-ammonium group knows how great an influence the question of detonating capacity exerts on the practicability of any given explosive for mining purposes. None of the nitrate-of-ammonium explosives can be guaranteed to always detonate perfectly, the main drawback lying in their hygroscopic properties. Wherefore it is the more urgent to secure in the case of these explosives the greatest and readiest detonating capacity attainable, and the manufacturers should be unceasingly impressed therewith, because it is precisely for want of detonating capacity that safety-explosives are so often discarded.

With regard to the second limiting factor, it is found that concurrently with the decrease in quantity of the carbonaceous constituents the blasting efficiency of an explosive is seriously diminished. This will be observed by a glance at the figures in the last column of Fig. 1 (Plate IX.), while with 17 per cent. sekurit, the expansion of the lead cylinder amounted to 470 cubic centimetres, with an identical charge of 4·75 per cent. sekurit, the expansion was only 290 cubic centimetres.

It is true that improvements have been accomplished in both directions in the case of two of the nitrate-of-ammonium explosives, dahmenit A and roburit I. They are more especially interesting in this respect that we know them under two similar but distinct forms (proportions of composition).

Ritter von Dahmen, by simply adding 2½ per cent. of bichromate of potassium to dahmenit, produced the so-called dahmenit A, increasing enormously thereby the degree of safety of the explosive without weakening its shattering power. Fig. 1 (Plate IX.) shows that fire-damp mixtures containing 7 per cent. of the gas were ignited by a dahmenit charge of 8·82 ounces (250 grammes), while with dahmenit A the same mixtures only began to ignite regularly at the charge of 19·75 ounces (5 · grammes). In the case of this explosive the expansion of the lead cylinder amounted to 502 cubic centimetres, as compared with 495 cubic centimetres in the case of the other one.

The extraordinary effect of this small percentage of bichromate of potassium is attributable to the fact that it decomposes with relative ease

a dull red heat, and in decomposing captures a part of the heat developed on detonation of the explosive, reducing, therefore, by that much the total amount of heat set free by the detonation. Moreover, the facility with which the bichromate decomposes, increases the detonating capacity and rapidity of ignition of the explosive. As a matter of fact, dahmenit A, when perfectly fresh, can be made to detonate perfectly with No. 3 detonators (containing 0·054 gramme or 8·33 grains of fulminate of mercury), whereas in practical work the detonators used contained 2 grammes or 31 grains of fulminate of mercury.

A similar principle has been applied in the cases of progressit and roburit I, and apparently also in that of the Cologne-Rottweiler safety blasting-powder, the composition of which has not yet been determined by chemical analysis.

With roburit I, by adding 4 per cent. of permanganate of potassium, the proportion of the carbonaceous constituent (dinitro-benzol) has been reduced to 7 per cent. without the detonating capacity of the explosive suffering in the least therefrom. Using No. 4 detonators, the fresh explosive, even in 1·06 inches cartridges, was caused to detonate perfectly, and yet at the same time its degree of safety is so high that a charge of as much as 21·16 ounces (600 grammes) failed to bring about ignition of a gaseous mixture containing 7½ per cent. of fire-damp. It is true that the blasting efficiency of this explosive is less conspicuous than that of the older form of roburit, so far as one can judge from the experiments made with the leaden cylinder. But this is solely attributable to the diminished proportion of dinitro-benzol, for a comparison of the numerical expressions for shattering-power for roburit I in Fig. 1, and 8 per cent. sekurit in Fig. 2, will show that the addition of the permanganate of potassium has in nowise injured the blasting efficiency of the explosive. The expansion of the leaden cylinder caused by the one was 365 cubic centimetres, and that caused by the other 358 cubic centimetres.

The examples that have been considered in these pages show that, as a matter of fact, there has been great progress of late in the manufacture of safety-explosives, and the progress thus far achieved justifies the hope that it will be possible to remove one great drawback attached to the safety-explosives of the nitrate-of-ammonium group—namely, that in order to make these explosives detonate very strong detonators (which of themselves constitute a source of danger) have to be used.

As to the easy manipulation, or otherwise, of these most recent forms of safety-explosives, in the practical working of the mine, the writer has no experiences of his own to record, for he has had little opportunity of

gaining such experience. What he hears, however, from We colliery managers emboldens him to state that these explosi yielded extremely satisfactory results when used in the coal.

The following paper by Mr. Lohmann on "Shot-firing in I Dusty Mines" was taken as read :—

The Federated Institution of Mining Engineers
Transactions 1895-6.

To illustrate Mr. Winkhaus' Paper on "Safety Explosives."

Vol. X Plate IX

FIG. 1.

BEHAVIOUR OF EXPLOSIVE.

INCREASE OF VOLUME OF THE

COMPOSITION.	BEHAVIOUR OF THE EXPLOSIVE.			TEMPERATURE OF DETONATION. CENTIGRADE.	INCREASE OF VOLUME OF THE LEADEN CYLINDER, WEIGHT OF CHARGE, 0·35 OUNCE (10 GRAMMES) CUBIC CENTIMETRES
	PARAFFINED CARTRIDGES.	NON-PARAFFINED CARTRIDGES.			
	WITH COAL-DUST.	WITH COAL-DUST.	WITH 7 PER CENT. FIRE-DAMP.		
[illegible]	[illegible]	7·93	76	2200°	470
[illegible]	[illegible]	[illegible]	[illegible]	2047°	457
[illegible]	7·94	[illegible]	[illegible]	1870°	456
[illegible]	9·52	17·64	12·35	1696°	365
[illegible]	17·64	17·64	17·64	1482°	290

OXYGEN-SUPPLYER. CARBON-SUPPLYER. IGNITION NON-IGNITION

North of England Institute of Mining & Mechanical Engineers
Transactions 1895-6

Vol. XLV. Plate IV.

SHOT-FIRING IN FIERY AND DUSTY MINES.*

By BERGRAT H. LOHMANN.

The writer proposes to confine his remarks to a brief examination of the present state of the question embraced by the title of his paper, dwelling in the main on those points which appear to be of the greatest practical importance. He will hold himself excused therefore if it is found that he has to recur once and again to certain well-known facts.

The Prussian Fire-damp Commission, in the course of the investigations conducted by them in the experimental gallery at Neunkirchen (which were mainly concerned with the behaviour of different varieties of coal-dust in the case of blown-out shots fired with blasting-powder), ascertained beyond a doubt that dry coal-dust was dangerous under such circumstances. They, moreover, took the opportunity of making a few experiments with high explosives, and achieved strikingly successful results. Apart from the fact that these results were traded on by competing manufacturers, they were much over-estimated when we consider the inadequacy of the experiments, and then too the erroneous conclusion was arrived at that the degree of safety of a high explosive was also a measure of its blasting-power, the two being supposed to increase simultaneously. Opinion in Germany was at that time far on the road to an absolute prohibition of ordinary blasting-powder and to the unrestricted use of high explosives. At that very time the writer uttered a warning, and not in vain, as to the danger of setting too high an estimate on the behaviour of such explosives in the presence of fire-damp and dry coal-dust; his warning was based on a new series of experiments started at Neunkirchen.

Meanwhile developments have been proceeding satisfactorily: that the particular characteristic which makes a high explosive a safety-explosive, in comparison with others, is first and foremost the low temperature of the explosion-gases has been duly recognized by German observers, while the French have placed it firmly on a theoretical basis. Various safety-explosives have been developed within the group of high explosives: they have been introduced into a number of collieries in place of blasting-powder, which is being gradually banished from mines with soft and

* Translated by L. L. Belinfante, B.Sc.

dusty seams. The use of these new substances has been more a matter of necessity than of choice, but at any rate experience has shewn that the change has not produced any notable rise in expenditure (take, for example, the König pit) in the matter of shot-firing.

The ideally perfect safety-explosive is still to seek: continuous endeavours are being made to that end, and they are fruitful enough to afford hope, but the battle is not yet won. Again the writer would utter a warning not to over-estimate the value of safety-explosives to such an extent as to force collieries where the use of blasting-powder is attended with very little danger to give it up; and, when safety-explosives are used, the writer would urge the unadvisability of minimizing the need for the customary safety regulations. These will be directed towards the attainment of three main points:—(1) The removal of whatever is likely to give rise to an explosion, wherefore by means of adequate ventilation fire-damp must be rendered harmless, and similarly coal-dust must be made innocuous by watering. (2) If, notwithstanding these precautions, an explosion does take place it must be localized, and this is feasible by forming wet zones, and by splitting the air-currents. By the fulfilment merely of the conditions just enumerated disasters on a large scale will be avoided. (3) Anything that is at all likely to cause ignition of fire-damp and coal-dust must be discarded. Under this order of consideration comes the employment of suitable safety-lamps that are lighted from within, and are provided (when used at working-faces where there is much evolution of fire-damp) with double-gauzes. Moreover, shot-firing must be reduced to a minimum at specially dangerous spots, and then only carried on with safety-explosives or safety-cartridges and safety-fuzes. The precautions enumerated under the third heading are the only ones that may fail to secure the end in view, and this because, in addition to chance accidents which will happen despite the best safety-lamps and the safest explosives, too much depends on the manner in which various people carry out their instructions, even though special shot-firers be employed.

All this being granted, the writer will say a word of warning as to placing too high the standard of safety for explosives. There is no very great difficulty in manufacturing high-grade safety-explosives, whose standard of safety is far higher than that usually attained, and by dint of puffing them in the proper quarters, one may easily succeed in exalting them at the expense of other explosives which have proved satisfactory in every-day mining practice. But the final result of this method of puffery is in most cases as follows:—The much belauded new safety-explosive proves impracticable by reason of its inefficiency as a blasting

it, or, that inefficiency being recognized, its composition is secretly ıged at the expense, more often than not, of its safety. Experiences nis kind are naturally wont to prevent the miner from abandoning a paratively unsafe explosive in favour of a safer one.

But to solve the problem as to what is the minimum standard of ty which will justify the manufacturer in dubbing any particular losive a "safety-explosive," we must have recourse in the future as in past to experiment on a large scale. By that the writer means the al use of the explosive in fiery and dusty mines. Cases are known Vestphalia of fires in the pit caused by safety-explosives. In the part of this year, the writer and Mr. Winkhaus investigated these on the spot, but they are too scattered to justify the deduction of very definite conclusions from them.

t is, at all events, a mistake to regard as a decisive measurement of afety of an explosive the result of any given experiment made in the imental gallery. Apart from the fact that, from causes hitherto ignable, the different galleries appear to be affected differently by ar conditions of ignition, the conditions actually obtaining in the an never be reproduced with sufficient exactness, and therefore their for purposes of comparison is purely conditional. It would be l more grievous mistake to base any practical conclusions on the t of a theoretical calculation of the temperature of the gases pro- l on explosion, because we have really nothing by which to gauge ıfluence of accessory circumstances. The temperature of the gases t the only point demanding consideration; we have, for instance, to into account the presence of certain other gases or of finely divided particles in suspension.

peaking from this standpoint, the writer concurs most absolutely Mr. Winkhaus in urging that the determining condition of further ress in the matter of safety-explosives is the minutest possible stigation of every case of ignition in a mine brought about by a y-explosive. The materials thus accumulated must be systematically ıged, carefully digested, and published. For the fulfilment of this , much time and labour will be needed, as well as the moral support of Government mining authorities.

The following addendum to Mr. E. Halse's paper on "The Quicksilver ıes and Reduction-works at Huitzuco, Guerrero, Mexico," was taken ead:—

THE QUICKSILVER MINES AND REDUCTION-WORKS AT HUITZUCO, GUERRERO, MEXICO.*

BY EDWARD HALSE.

ADDENDUM.

Since the above paper was written, an article by Mr. W. H. Rundall has appeared on the "Mining and Treatment of Quicksilver Ores at Guadalcazar, Mexico."† He says that at the Trinidad mine, owned by an English company, the formation is limestone, which has been largely replaced in parts by gypsum :

The occurrence of the ore in this mine is very irregular, but there may be said to exist one main ore-shoot which has been followed through a horizontal distance of about 200 metres (656 feet), and a vertical distance of about 60 metres (197 feet). The upper part of this shoot consisted of a mass of irregular stringers of ore running in all directions through broken-up limestone-rock, and forming stringers and pockets in the solid gypsum, which in turn occurs in irregular but connected masses replacing the shattered country-rock or limestone. . . . . As the ore-shoot was followed and explored in depth, the ore took a more massive form, occurring in large bodies and increasing in richness. At one point a large body of soft, black ore was discovered, averaging from 7 per cent. to 10 per cent. of mercury, completely enclosed within a solid mass of gypsum. The ore when occurring in the gypsum is usually a mercury selenide of an iron-grey colour, granular, soft, and giving a purple streak. . . . . In the lowest slopes the ore occurs in silicified limestone-rock, in parts much shattered and considerably mixed with clear transparent gypsum and fluorspar. . . . . A little to the south of the ore-bearing workings the limestone is intersected by a dyke of decomposed porphyry. . . . A similar dyke cutting through limestone in the same district is yielding mercury ore of fairly good quality.

The secondary quicksilver ore of Huitzuco, known as barcenite, will become more and more rare as the surface-deposits are worked away. This mineral was discovered by Prof. D. Gumesindo Mendoza, was described by Prof. J. W. Mallet, and named by him after Prof. Mariano Barcena, the Mexican geologist.‡

Prof. Mallet regarded it as a mixture of sulphide of mercury, antimonic acid or an ochre of antimony (Sb_2O_5, $5H_2O$ or $H_4Sb_2O_7$, $3H_2O$), and an antimoniate of lime, mercury, and Sb_2O_5, with the formula—

$$\left.\begin{matrix} R''O_4 \\ Sb_2O_8 \end{matrix}\right\} 5(Sb_2O_5), \text{ where } R''O = HgOCaO.$$

The writer regrets to say that Mr. Romero Rubio, who owned the Huitzuco quicksilver mines and works, died quite recently at his home in Mexico city.

The meeting then terminated.

* *Trans. Fed. Inst.*, vol. x., page 72. † *Engineering and Mining Journal* [New York], June 29, 1895, pages 607, 608, with three views of the furnaces used.

‡ *Boletin de la Sociedad de Geografia y Estadistica de la Republica Mexicana, terciera época*, vol. iv., pages 270-283 ; also *American Journal of Science* for 1878.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,

HELD IN THE MASON COLLEGE, BIRMINGHAM, DECEMBER 5TH, 1895.

MR. J. H. COOKSEY, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and of the Council Meeting were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. JAMES TARDIF BROWNE, Mining Engineer, Nuneaton.
Mr. PETER NEVILLE MARSH, Colliery Manager, Tamworth.
Mr. JAMES LOFTUS OWEN, Civil Engineer, Colmore Row, Birmingham.

Mr. G. TURNER read the following paper on "Coal-Mining in Assam, India":—

COAL-MINING IN ASSAM, INDIA.

By GEORGE TURNER.

It is now just over thirteen years since the writer went out to Assam, India, taking with him over fifty British workmen for the Assam Railway and Trading Company, Limited, a company then just formed in London to make a metre-gauge railway in the Lakimpur district of Assam, from Dibrugarh, on the banks of the river Bramaputra, north-east towards Sudyia, through extensive tea-plantations, with a branch-line 30 miles long, passing through primeval forest-land to the Makum coal-field, situated on the first range of the Patkai Naga hills. Collieries were to be opened out and the other resources of the country developed, including the extracting and refining of petroleum, erection of saw-mills, exportation of timber, brick and pottery-works, tea-gardens, etc.

The existence of coal in Upper Assam is said to have been known from the earliest period of the British occupation of that province, but the first recorded notice appears to have been made by Lieutenant Wilcox in 1825. Since then various attempts have been made to work the coal; at different points in 1828 some 5,000 maunds, or about 185 tons, was quarried at Saffrai, but on account of the difficulties of communication in the unopened country, the scarcity of labour and food supplies, and the unhealthiness of the places where the coal was found, every attempt to open up the coal-fields of Assam prior to 1882 entirely failed. Between 1874 and 1876, Mr. F. R. Mallet, of the Geological Survey of India, made a survey of the Assam coal-fields, and his report was published by the Government.* Concessions for working these coal-fields were granted to the Assam Railway and Trading Company in 1881. No time was lost in commencing operations, and since then over £1,000,000 has been expended on their various enterprises.

Mining Concession.—The company's mineral concession has an area of 30 square miles, being about 9 miles long, with an average breadth of about 3¼ miles. In this area is the first range of the Patkai Naga hills, which rise about 1,100 feet above the plains. This range is cut through at nearly right-angles, about 3½ miles apart, by rivers which carry the

* "Coal-fields of the Naga Hills, . . . Assam," by Mr. F. R. Mallet, *Memoirs of the Geological Survey of India*, vol. xii., page 269, and 3 maps. "Coal of Assam," by Mr. H. B. Medlicott, *Ibid.*, vol. iv., page 387, and map.

water from the hills and expose the outcrops of the coal-seams at the lowest points. Coal has been proved in these hills over the whole length of the company's concession, and as coal of very nearly similar description is found in the hills 20 miles eastward and 30 miles westward, there can be no doubt as to the existence of a large coal-field. The coal in the hills is found at various heights from zero in the plains up to 1,000 feet above them. The hills conform in longitudinal direction with the strike of the rocks, although they do not form a continuous ridge, being cut through by several streams. The coal has a high dip towards the hills, the average being about 1 in 3, but sometimes it is as high as 1 in 2. A distinct break in the strata and line of upheaval along the foot of the hills is traceable for a considerable distance; the same section of coal is found ½ mile distant dipping in the opposite direction, and there is no doubt that these form one and the same seam, separated and thrown apart by pressure causing upheaval (Plate X).

Rain-fall and Climate.—The climate of Assam is variable, damp and enervating. In the hot season the maximum temperature is over 100 degs. Fahr. in the shade, in the cold weather it falls to 40 degs. Fahr.

The average rain-fall during the year is about 100 inches, the most part of which falls in the four hot months—June to September; it is not uncommon to get 25 to 30 inches of rain in one month, and the writer has known 6½ inches of rain-fall in one night, when rivers overflow their banks and the lower parts of the country get flooded.

Quarries.—While the collieries in the hills were being opened out, a quarry, along the line of outcrop in the plains, was worked, and for some time a large quantity of coal was so extracted. This seam had a very high dip, viz., 1 in 1, the section of the seam corresponding to the section of the seam in the hills, but after the hill collieries were ready for work this quarry was closed. Owing to the heavy rain-fall, it is not deemed desirable, so long as there is sufficient coal in the hills above the water-level of the country to supply all possible requirements for the next 150 years, to resume working in the plains below the water-level.

Collieries.—The company have in all four separate collieries, three at work, and one in course of development; two of these collieries are situated on the sides of the rivers, which break through the hills at a level only a few feet above the plains at points where the outcrops of coal are exposed at the surface. The distance between these two mines is about 3½ miles; and it is proposed to drive underground roads to connect them with each other, and half of the area of coal will be wrought

Two others collieries, situated some distance up the mountains, are working the same coal-seam, taking off a portion of the higher level coal. The workings of one of these collieries already extend to over 1 mile from the entrance.

The coal-measures consist of alternating shales, sandstones, with a few thin calcareous layers, and several workable seams of coal, but the lowest thick seam comprises from 40 to 50 feet of coal, separated sometimes by only two shale-partings a few inches thick; while at other points these partings increase both in number and thickness, so as to divide the coal into three or more separate seams. The following is a section of coal that was being worked in April last:—

	Ft.	In.	Ft.	In.
Coal	15	0		
Shale partings	0	9		
Coal	13	0		
Shale partings	1	0		
Coal	24	0		
			53	9

Where the coal-seam is similar to the above section, it is wrought in one working; but when the partings increase in thickness, as they often do, in a few hundred feet, from as many inches to as many feet, the upper and lower sections of coal are worked separately, usually leaving the middle coal, and working what is possible of it from the lower openings as they break down. In one case, the seam being in three divisions, with partings from 7 to 9 feet thick, an endeavour was made to work all three of them alternately, as an experiment, beginning at the top, but it was found impossible to extract so great a quantity of coal from the working of the three seams as from the working of the upper and lower one.

Systems of Working.—The system of working adopted is very similar to that adopted for working the thick coal-seam of South Staffordshire, and it has been found to work well, considering the thickness and nature of the coal to be dealt with.

Starting from the outcrop, two parallel roads are formed, about 90 feet apart, and driven out in the bottom portion of the seam, with the strike of the coal, having a gentle rise in favour of the load, and so that the water will just flow out freely to the entrance of these roads. Bolt-holes or cross-roads are driven at intervals of 120 feet to connect the roads together, and for the purposes of ventilation. The lower main-road is used as a haulage and drainage-road, while the upper road serves as a ventilating and travelling-road.

When the bottom-roads have reached a certain distance into the hill, other roads are formed 90 feet apart, and driven to the rise at about an angle of 65 degs. from the bottom-roads. When these hill-roads have reached a safe distance, say 200 to 250 feet, from the bottom main-roads, other roads are formed and driven along the strike of the seam for a distance of 1,200 to 1,500 feet parallel to the bottom main-roads. Here sides of work are formed, and the operation of working out the coal commences. One of the hill-roads is made into a self-acting incline, conveying the coal to the bottom-level, the other road serving as a ventilating and travelling-road. The sides of work are usually formed about 120 to 140 feet square, allowing in the thickest seam of three 30 feet openings, and two rows of pillars 24 feet square, and in the thinner seams of three 27 feet openings and two 18 to 21 feet pillars.

Ladders and planks are used, and the coal cut up overhead and dropped in the usual fashion up to a height of 16 to 17 feet; after this the upper coal is either brought down by its own weight or is blasted. The pillars are often varied in size, and sometimes taken out altogether, according to the thickness and nature of the seam. If spontaneous combustion threatens in the early working of a side of work, the pillars may be dispensed with and a small cross-rib left, dividing the side of work into two parts.

In the mines, the coal is fairly hard and compact, but it is brittle, and disintegrates very quickly on exposure, probably due (*a*) to lamination, giving the coal a tendency to exfoliate; (*b*) jointing on a small scale; (*c*) the presence of minute particles of pyrites; and (*d*) crushing of the coal from pressure.

The roof over the coal-seam is shale, and it usually breaks down freely as the coal is worked out.

In the workings spontaneous combustion quickly ensues. Every precaution is taken, the entrances to the sides of work are kept small, and materials for sand-stoppings are always at hand. Previous to going out to India, the writer had an extensive experience of spontaneous combustion in mines, but he knows of no mines where it occurs so quickly as in the Assam coal-mines.

Water.—A large quantity of water continually finds its way into the mines from the surface. In the rainy season the quantity is often much greater than can be dealt with by the ordinary pumps, but by keeping all the roads above the water-level of the country, and making the lowest road the drainage-road, the water flows away without trouble or expense.

Labour.—Around the mining area, and back in the hills are found aboriginal tribes, called Nagas, a fairly strong race of people. At first, these tribes threatened to exterminate us if we did not go out of what they claimed as their country, but since then they have become more or less civilized and friendly.

These people, as a race, are incorrigibly lazy, having no industries of any kind, and cultivating only sufficient grain for their own consumption. When wanting money to purchase opium, salt, or other necessaries, they will work for a short period in cutting or clearing jungle or similar work, but nothing will tempt them to commence mining. There is no other available labour in the Assam province, consequently all the labour employed at the mines underground and on the surface is imported from other parts of India, but chiefly from Bengal. The scarcity of labour is one of the great drawbacks to coal-mining in Assam, and it is not always easy to procure the class of workpeople best suited to the Assam climate. Moreover, the cost of the labour agencies forms a very considerable item of the expenditure.

The Indian coolie is much below the standard of the British labourer, but give them time, provide enough working-places, employ them in sufficient numbers under European supervision, and good results can be obtained. When first imported they do not like the idea of mining work at all, and at first are usually put to surface work for a time, when their prejudices give way, and they afterwards prefer underground work.

A variety of castes of coolies are imported, but the castes of Santals, Moondas, Oorangs, Kols, Dhangurs, and Bouries suit the Assam climate best, and make the best miners. At first, coal-mining coolies were engaged from the Bengal coal-fields, but these on arrival wished to work in their own primitive native fashion, using a *sabol* (a crow-bar pointed at both ends) for cutting the coal, instead of a double-ended pick, and so on. As the mining required from them was unlike anything that they had seen or done before, it was soon found out that to introduce the South Staffordshire method of getting thick coal in India it would be better at once to begin at the beginning, and train up to the work young natives, who had never seen a coal-mine, under selected thick-coal miners. This was done, and there are now hundreds of native working in the mines, careful and good workmen, who were agriculturists a few years ago. The same may be said about other branches of the company's works. There is ample surplus skilled labour in other parts of India, but on account of the unhealthiness of Upper Assam, and

nce (1,000 miles) from Calcutta, there is no supply of skilled ır in Assam to draw upon. If an engine-driver, platelayer, or other ın is wanted, an agriculturist must be taken and trained to the . As a rule, they are quite willing to learn anything that you may to teach them, and in time make fairly good workmen.

oth men and women work in the mines, the men cutting and ıg the coal, timbering, etc., the women filling tubs, tramming, etc. work as much as possible in gangs, each caste of workpeople pre- ıg to keep together, having one of their own caste over them as r or native ganger.

Then imported from other parts of India, they come up in batches, sting of whole families, and also single men and women. Young about twenty-two years of age, are preferred, but one must take as they come, men, women, and children. If, say 100 good young miners are wanted, one must import about 300 persons in order to e what is wanted, and all have to be housed, fed, and provided for. e are engaged, under a properly executed agreement, in their own ıry, for a term of three years, the agent making them presents of y and clothes or advances, and paying all expenses *en route*. Each e costs about 120 rupees, or £7. The employer provides houses, cal attendance, and comforts free, and every fortnight rice (imported Bengal) at about two-thirds of its actual cost. Blankets and warm es are also supplied to them in the cold weather. All new coolies ingle coolies are fed daily by the company in hotels, at a charge of t two-thirds of the actual cost. The wages of the coolies, when first rted, is fixed for the first three years—men, 8 rupees; women, 7 rupees hly, for a full month's work of eight hours per day, Sundays excluded. three years, they are re-engaged at advanced wages, according to worth. The following are the rates of monthly wages paid :—

	Rupees.		Rupees.
s	15	Engine-drivers	15 to 16
utters	10 to 13	Rope-followers	12
illers...	8 to 9	Platelayers	10 to 12
rmen	12	Horse-drivers	8
smen	8 to 10	Women	7 to 8
men	8 to 10	Boys	5

value of the rupee to-day is just under 1s. 2d., and the above rates ıges, although appearing low to an Englishman, are double or treble the coolies could earn in their own country. A coolie can live on 5 rupees monthly, and their earnings enable them to make what to are considerable savings.

Taking the average work performed by a certain number of coolies, it is generally assumed that it takes three coolies to perform the same work as one European would do in his own country.

The output from the Assam mines, per labourer employed, including surface and underground, and calculated on working six days per week, is about 170 tons per labourer per year. Everything is made as easy as possible for the labourers at the mines, rails are laid, tubs taken to the faces of working, mines well ventilated with fans, and everything done, as in a modern English colliery, to economize labour. Although the actual labour is cheap, it entails responsibilities and other expenses outside of the mere pay-sheets, for importing, housing, feeding, clothing, medical attendance, sanitation, etc., which, together with the health of the labourer, often give the management more anxiety than the actual work itself. The manager consequently tries to save labour whenever he can, by the adoption of mechanical haulage, etc., even when there may not be any monetary advantage in it.

Tramways.—The tramways, both underground and surface, are of 2 feet gauge. At first 16 lbs. rails were used, but now 22 lbs. rails are adopted, with wooden sleepers. The heavier sections have been found to be most economical.

Tubs.—The tubs are made some of wood, and some of iron. All are made on the spot, except the cast-steel wheels and axles, which are sent out from this country. The iron tub is found to be the most economical. Some time ago steel-plates were used for the tubs instead of iron, but these were found, owing to the mine-water, to oxidize much more quickly than iron.

Haulage.—Down the hills, haulage is effected by self-acting inclines, and on the level by either ponies or main-and-tail ropes. The endless rope would have been adopted had the roads, which, as a rule, stand well and without timber up to about 6 feet wide for a single line of rails, not required extensive timbering when made sufficiently wide to admit of a double line of rails.

Mining Timber.—Timber is obtained from the forests adjacent to the mines, but being a quick-grown tropical timber it does not last long when in use. Consequently all roads are driven about 6 feet wide and arched somewhat at the top, so as to use as little timber as possible.

Ventilation, etc.—Each colliery is ventilated by a ventilating-fan, the Schiele and Walker double-inlet fans giving good results. The mines are always examined with a safety-lamp previous to commencing work. Open kerosene-oil lamps are chiefly used for lighting, the kerosene-oil

being supplied from the company's own oil-works. Small quantities of gas are occasionally found in a few places, chiefly in the driving-out roads, where safety-lamps are used. In the hot weather the temperature of the mines is below that of the outside atmosphere. In the hottest months the temperature in the shade sometimes exceeds 100 degs. Fahr., and in April last, when the outside temperature varied between 76 and 82 degs., the temperature in the mines varied between 70 and 80 degs. Fahr.

Petroleum.—One peculiarity of this Assam coal-field is the quantity of crude petroleum and gas that is finding its way through the rocks to the surface, almost parallel to the line of outcrop of the coal-seams along the axis of the break of the strata for some miles in length. It was thought at first that the presence of this petroleum, with the large quantities of gas continually given off from it, may some time or other connect with the coal-mines and become a source of danger, but so far, although there are about 15 miles or more of underground roading in the hills, no trace of petroleum has yet been met with therein. When boring for petroleum, a very great thickness of fireclay and shale is passed through. The petroleum is, as a rule, always found in a soft, porous sandstone, and although some scientists believe that petroleum originates from other sources than coal, a study of this coal-field leads one to question whether the petroleum found there is not the result of pressure, heat, and natural distillation of a highly volatile and bituminous coal at the time of the upheaval of the hills, the liquid finding a receptacle in the porous sandstone-rocks.

Quality of the Coal.—The following comparative analyses show the quality of Assam coal as compared with English and other Indian coals :—

Description of Coal.	Carbon.	Hydrogen.	Oxygen and Nitrogen.	Sulphur.	Ash.	Moisture.
English (average of 47 samples) ...	81·979	5·156	7·946	1·295	3·387	?
Bengal (average of 6 samples) ...	74·480	4·550	10·010	0·470	0·510	?
Assam	75·700	6·047	13·107	1·390	1·120	2·636

Assam coal may be described as highly bituminous, it is very soft, cakes freely when being burnt, and in practical tests is found to be about equal to Welsh coal. It yields 10,900 cubic feet of gas to the ton. At first some objection was taken to the Assam coal on account of its smallness, similar to the rough slack of this country. Fire-bars had to be put closer, and (on account of the great heat given off) made in shorter lengths to allow of the use of the coal. When this was done and the coal once used all prejudices disappeared, one and all acknowledging it to be the best coal in India.

Output and Demand.—The quantity raised and vended has risen from 16,493 tons in 1884 to 169,835 tons in 1894, and arrangements are now being made to greatly increase the output within the next few years, as the demand is fully maintained and keeps pace with the supply. The markets for the coal are found locally on the tea-estates in the district, steamer consumption on the Bramaputra river, jute-factories, railways, ocean steamers at Calcutta, etc. From the mines, the bulk of the coal is conveyed by railway to Dibrugarh, a distance of about 70 miles, and there transhipped into steamers and flats for conveyance to the different depots on the river and to Calcutta, the latter place being over 1,000 miles distance.

The steamers and flats used are flat-bottomed, drawing about 6 feet of water when laden. The steamers carry coal for their own consumption, and several hundred tons for the markets; while the flats carry coal for the market up to 1,100 tons each. One steamer tows from one to three loaded flats, and occupies about six weeks in the round journey.

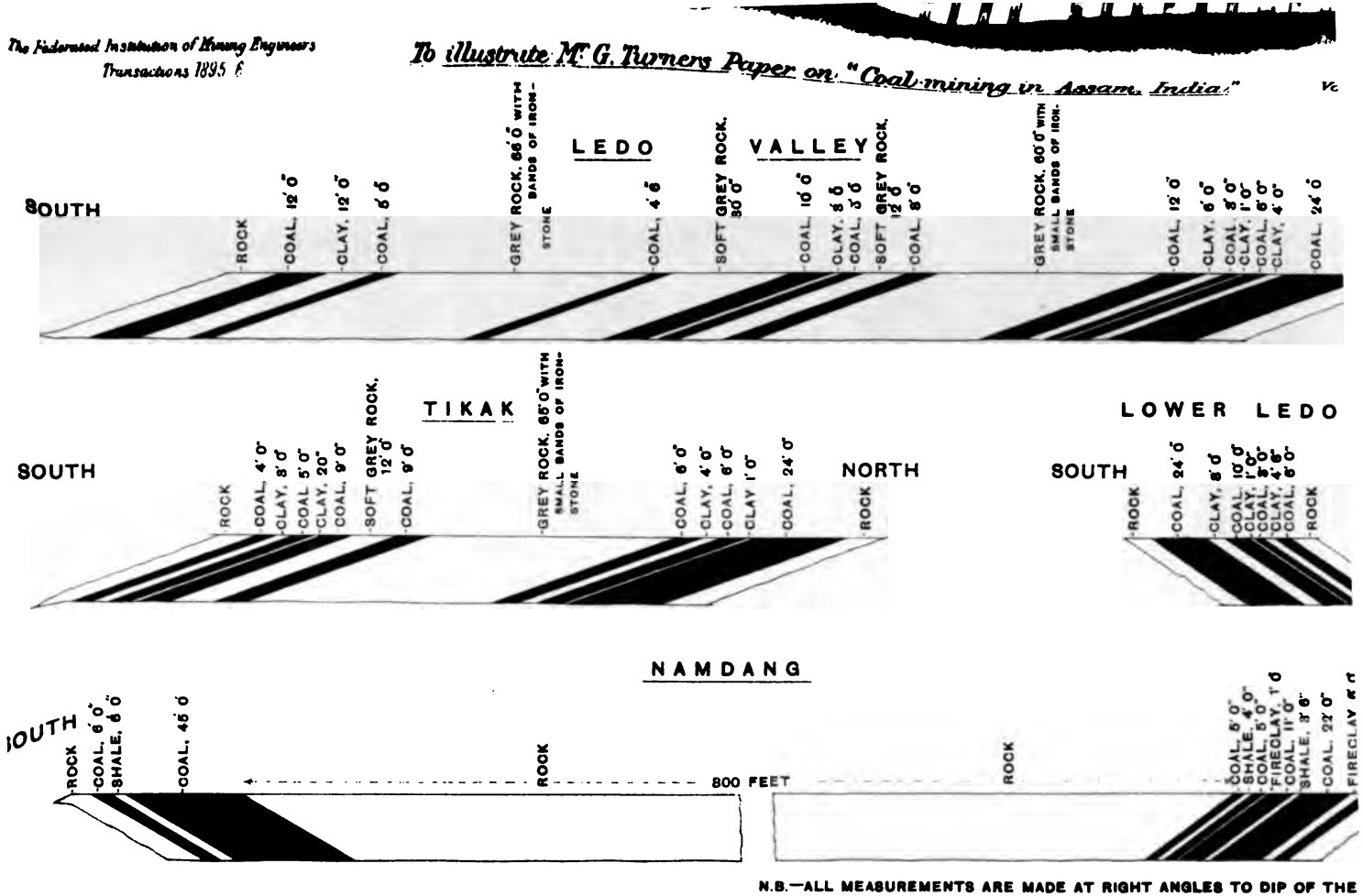
General.—In dealing commercially with the undertaking, Indian, like all other coal companies, must look to the question of profit and loss, and the writer may state that while coal-mining in India is more costly in some details than in England, the cheap Indian labour enables coal to be raised at a rate much lower than in Great Britain. Further, although distances from the mines to the markets are, as a rule, far greater than in England, the low rates for railway carriage of coal (being only about one-fourth of what they are in this country) place Indian coal in a position to compete favourably on the Eastern markets with English fuel. There can be no doubt that, in course of time, India will produce all the fuel that she requires for her own use, and will export coal to other ports in large quantities.

In conclusion, the writer may say that in this paper he has tried rather to give the members a *résumé* of the conditions under which mining undertakings are worked in Assam rather than numerous details of the workings themselves. In Assam, working under different conditions from those that obtain in Great Britain, the object is to lay out the mines and work them as nearly as possible up to the standard of a modern English mine.

A vote of thanks was passed to Mr. Turner on the motion of the PRESIDENT, seconded by Mr. ROBERT S. WILLIAMSON.

The Federated Institution of Mining Engineers
Transactions 1895 6

To illustrate Mr G. Turners Paper on "Coal-mining in Assam, India."



N.B.—ALL MEASUREMENTS ARE MADE AT RIGHT ANGLES TO DIP OF THE

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE ROYAL VICTORIA STATION HOTEL, SHEFFIELD, NOVEMBER 16TH, 1895.

MR. JOHN NEVIN, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated :—

MEMBERS—

Mr. JAS. GREGORY, Assistant Colliery Manager, Lowood Villa, Deepcar, Sheffield.

Mr. ALFRED HODGKISS, Colliery Manager, The Grange, Coppnell, Chorley.

Mr. JOHN KNOWLES, General Manager, The Pearson and Knowles Coal and Iron Company, Limited, Wigan.

Mr. JAMES LAMBERT, Manager, The Hulton Colliery Company, Limited, Bolton.

Mr. HENRY E. MALTBY, Colliery Manager, Lidgett Colliery, near Barnsley.

Mr. WM. PEET, Mechanical Engineer, 8, Park Terrace, Worsborough, Barnsley.

Mr. FRANCIS JOSEPH SPENCE, Mining Engineer and Metallurgist, 94, South Terrace West, Adelaide.

Mr. RICHARD SPENCER, Mining Engineer and Surveyor, Hanover Square, Leeds.

Mr. THOMAS ALLEN TURNER, Mining Surveyor, Aldwarke, Rotherham.

ASSOCIATE MEMBERS—

Mr. GEORGE DUNSTON, Colliery Proprietor, Hatfield Grange, Doncaster.

Mr. JOHN GRANGE FIRTH, Engineer and Colliery Stores Factor, Hunslet New Road, Leeds.

Mr. PERCY WILLIAM DOUGLAS STANDRING, Agent and Secretary, Strafford Collieries, Limited, Barnsley.

STUDENTS—

Mr. CHARLES BURY, Mining Engineer's Pupil, The Dale, Conisborough, Rotherham.

Mr. CHARLES ERNEST LONGBOTHAM, Mining Student, Barrow Collieries, Barnsley.

Mr. CHARLES COWELL NICHOLAS, Mining Engineer's Pupil, 14, Avenue Road, Doncaster.

Mr. GEORGE WRIGHT, Mining Engineer's Pupil, The Dale, Conisborough, Rotherham.

THE LATE MR. RICHARD CARTER, C.E.

Mr. A. M. CHAMBERS (Thorncliffe collieries) said he had the melancholy duty of moving a vote of condolence with the relatives of the late Mr. Richard Carter on the occasion of his decease. Mr. Carter was one of the founders of the Institute, and he had rendered it undoubted services of the greatest value. He was President for several years, and always took the deepest interest in the affairs of the Institute. It had been a great misfortune that during the last few years Mr. Carter's health had not permitted him to attend the meetings as he used to do, but he was certain that the members of the Institute had the greatest affection and regard for him. He moved that an expression of their deepest regret at his removal from amongst them, and condolence, and of their appreciation of his high character be entered on the minutes, and forwarded to the relatives of the deceased gentleman.

Mr. C. E. RHODES (Aldwarke Main colliery) seconded the motion, saying that the Institute had incurred a great loss in the death of Mr. Carter. The older members of the Institute, those who were chiefly instrumental in forming the Institute, were being gradually removed from amongst them. Nobody had worked harder for that Institute than Mr. Carter.

The motion was carried in silence.

Mr. ALEX. REID read the following paper on "Methods of Closing the Tops of Upcast Winding Shafts":—

METHODS OF CLOSING THE TOPS OF UPCAST WINDING SHAFTS.

By ALEXANDER REID.

The use of the upcast shaft as a winding shaft is not, by any means, commendable, and to venture on a paper describing the necessary arrangements for closing the top of the upcast shaft, when used for winding, and for keeping the ventilating current constant in the mine, seems at the outset to be a subject of scant interest in progressive mining engineering.

While one would not think of laying out a new colliery of any magnitude with a view to the use of the upcast shaft for winding purposes, there are many cases where the demand for increased output can only be met by so using the upcast shaft. In the case of the Ffrwd and other collieries, where the shafts have been sunk of insufficient dimensions to allow of two cages passing in the shaft, a cage runs in each shaft with the head-gears placed tandem-wise. Consequently the construction of cages in the upcast shaft must be tolerated, and a method of closing the top of the shaft becomes necessary.

The method that first suggests itself is to completely fit the top of the fan-pit with a box, allowing room above the landing-plates for the cages, and this fan-box is itself enclosed in an air-tight chamber, in which there is space for unloading the cages and changing the tubs. Access to the cage is gained by a door, placed on the fan-box, and this may be hinged or made to slide, and when it is closed the door of the outer chamber can be opened. This arrangement resembles the ordinary double separation-doors of the mine, accompanied with the attendant troubles of opening and closing the same. The method is cumbrous and inconvenient, and at its best far from efficient, owing to the difficulty of keeping the doors and chambers air-tight.

Following on this we have the pit boxed in above the level of the plates, and an arrangement as shown in Figs. 1 and 2 (Plate XI.). The sliding-doors being automatic are certainly an improvement, but as in the case of the old arrangement at the Ffrwd collieries, where, owing to the severe shock, iron doors weighing 11 cwts. were employed (for

wooden doors were destroyed in a single day), the wear on the winding rope was very excessive. The shaft is 420 feet deep, and as the wind only occupies 17 seconds, there is little time for gentle handling of the pit-head doors. When these doors are half-open, there is a very heavy leakage of air, and although the time is short a very appreciable lull in the ventilating current is felt throughout the workings. An arrangement of pistons is suggested (Figs. 1 and 2) for lifting the sliding-doors, the valves being controlled by levers actuated by the ascending and descending cage. This arrangement, improved as it is, however, seems to suggest more complications than advantages.

Another automatic arrangement of air-doors, designed for the same shaft, is shown in Figs. 3 and 4 (Plate XI.), and it would probably be costly to erect, expensive to maintain, and, as with the sliding-doors, there would probably be a serious loss or leakage of air when the doors were half-open.

The arrangement designed by the writer for the top of the fan-pit is shown in Figs. 5 and 6 (Plate XI.), and has been working most successfully at Ffrwd No. 3 pit for the past two years. It consists of a wrought-iron casing *A*, enclosing the cage with a little clearance all round, built into the pit, and rendered air-tight from the bottom of the casing to the landing-plates. On the side of the casing communicating with the lower level *C*, a door, *D*, is hinged to the casing, and kept bolted to the angle-iron of the casing, as it is only required to be opened under such exceptional circumstances as taking off the cage for repairs. In the event of requiring to use the cage at the lower level for the reception of timber or materials, there is no possibility of any leakage from the casing.

It will be noticed in the plan of this arrangement (Fig. 6) that considerable clearance is provided between the cage and the casing on the sides next the conductors, and the writer is of opinion that greater efficiency would be obtained were the guides sunk into suitable recesses in the casing. The top of the shaft, flush with the landing-plates, is covered with a light wooden door *E*, which with its stays weighs about 1 cwt. The boarding of the door is made of crossed poplar boards enclosing brattice-cloth between them. The joint between the door and the landing-plates is made by india-rubber, and the winding-rope works through a hole in the centre of the door. Enveloping the capping of the winding-rope is a light wrought-iron pipe *F* (3 feet long and 6 inches in internal diameter) fitted with flanges at both ends. The lower flange of the pipe is bolted to a block of timber *G* (15 inches square by 6 inches thick),

which rests on the lowest pair of clamps of the winding-rope, these clamps being neatly tooled to prevent injury to the rope. An india-rubber buffer *H* (15 inches in diameter by 6 inches thick) is fixed to the upper flange of the pipe.

When the top cover of the cage enters the casing *A*, the pull of the fan is taken off the top door *E*, the winding-rope receives no shock in lifting the light wooden door, and the cage acts as a door closing the shaft above the level of the fan-drift.

With this arrangement, there is no loss of air by leakage and the ventilating-current is maintained in the mine during each winding. Recent measurements of the ventilation in the shaft showed a current of 62,132 cubic feet of air per minute with the cages in the pit, and of 64,109 cubic feet of air per minute with the door open and the cage in the casing, as shown in Fig. 5. The increased quantity is wholly due to the removal of the cage as an obstruction to ventilation.

This arrangement is applicable to upcast shafts with two cages in the pit, by the use of separate casings for each cage, and of separate doors upon the top of the shaft. The two casings could either be stayed together, or made as one casing with a central division. Where rope guides are used, receiving-rods are rendered necessary so as to secure rigidity, and to avoid any risk of the cages coming into contact with the casing.

Where detaching-hooks are employed, slight alterations of the details at the top of the pit will be necessary. The writer suggests as a suitable arrangement that the ears running on the guides of the door *E* (Fig. 5) should be fitted with small rollers, and that the door itself should be fastened together in two segments, capable of being split transversely with the guides. In the event of an over-winding, the small rollers inside the guiding-ears of the door *E* could be made to mount on short inclined wedge-shaped projections on the guides, at the limit of travel of the doors. The buffer tube *G F H* should be arranged so as to go through the detaching-frame and allow the detaching-hook to act. The doors, split open outwards, would be caught by the cage, at rest, after being detached from the rope, and a light wooden door could be placed on the top of the opening of the casing, so as to maintain the ventilating-current during the attachment of the winding rope to the cage. In the case which has come within the writer's experience, an automatic compressed-air brake applied to the winding-engines takes the place of detaching-hooks.

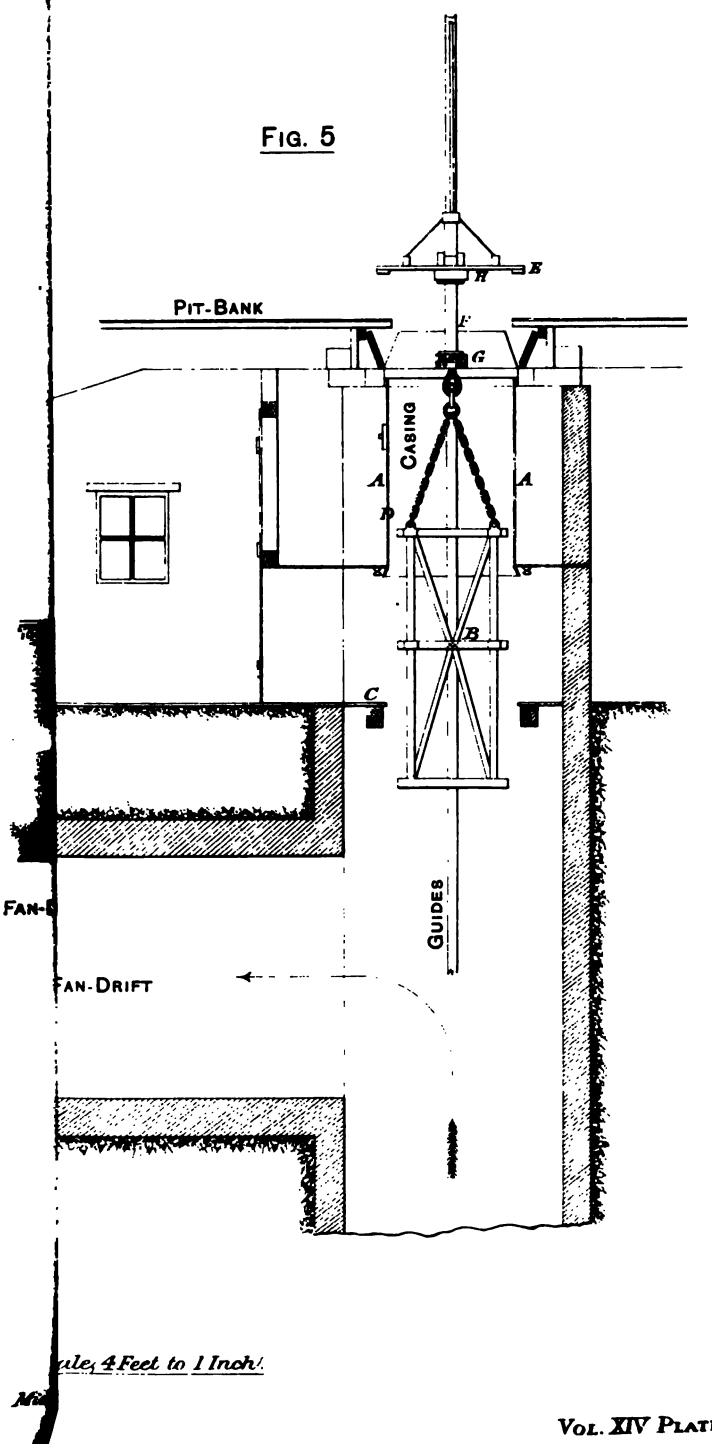
In conclusion, the writer claims the maximum of efficiency and convenience and the minimum of cost of erection and maintenance for this arrangement over any other method of closing the top of an upcast winding shaft.

Mr. C. E. RHODES (Aldwarke Main colliery) said that the utilization of the upcast shaft for winding minerals would necessarily increase in the future, on account of the great depths and the costly character of colliery undertakings. At Cadeby colliery, for instance, where the shafts were not only of great depth, and great difficulties had been encountered in sinking owing to the character of the strata, the sinking of a third shaft for winding purposes would have enormously increased the outlay, and therefore the utilization of the upcast shaft became a necessity. The arrangement described by Mr. Reid seemed to be a convenient one; at the same time he (Mr. Rhodes) thought that the best method of using an upcast shaft for winding purposes was to build a chamber at the surface large enough to take in the top of the upcast shaft and the other arrangements necessary for banking. A cage with two or three decks of coal could be raised to the surface inside this closed chamber, the self-acting doors being lifted by the cage. When the coal was banked and the cage left the surface these doors would be closed, and the coal could then be sent through a second door out of the chamber to the weighing-machine and to the screens by creepers, or any other method which was most convenient. He had found that system a convenient arrangement, and there was no difficulty in raising a very large quantity of coal per day without increasing the cost of banking. He (Mr. Rhodes) moved a vote of thanks to Mr. Reid for his paper.

Mr. G. BLAKE WALKER, in seconding the motion, said the paper had been of special interest to him, as he had been working out the details of a similar arrangement for some time past, but had not up till then been able to satisfy himself that it would work practically without trouble, and he had consequently, for the time being, abandoned the idea.

The PRESIDENT said he gathered that at Aldwarke colliery there was a door on the shaft which answered as one separation-door, and a door on the chamber which acted as the second separation-door.

FIG. 5



ale, 4 Feet to 1 Inch.

Mr. C. E. RHODES said that at Aldwarke colliery there was a box at the lower landing, so that the bottom of the cage acted as a door (more or less efficiently); and on reaching the surface, sliding-doors were lifted by the cages; when these doors were open the banking was done in the chamber, and the tubs were run through another door to the screening-belts.

Mr. REID was obliged to the members for the vote of thanks. He feared that at the outset of his paper he had spoken in condemnatory language of the system which Mr. Rhodes approved. Sliding-doors were tried at the Ffrwd collieries for many years, but the wear of the winding-ropes became excessive. Iron doors were used, and the wear and tear was 50 per cent. greater than that of the rope running in the downcast shaft. The system Mr. Rhodes described would work satisfactorily if light wooden doors were used.

Mr. C. E. RHODES stated that wooden doors were used at Aldwarke colliery.

Mr. REID said that wooden doors had been tried at the Ffrwd collieries, but they were speedily destroyed owing to the high speed of landing the cage on to the pit bank.

Mr. A. W. BENNETT read the following paper on "Telephonic Communications in and about Coal-mines":—

TELEPHONIC COMMUNICATIONS IN AND ABOUT COAL-MINES.

By A. W. BENNETT.

It is less than twenty years since Prof. Bell invented the first really practical telephone or instrument by which not only musical sounds but articulate speech could be transmitted, or reproduced, at a considerable distance from the speaker. Yet, when one considers the world-wide progress that has been made in the direction of speaking intercommunication, the writer may perhaps be excused if he attempts to eulogize, expecting yet greater things in the near future. It is not to the possibilities of talking with engineers in Europe, America, or Australia, that attention is here directed, but to the more homely matter of communications in and about collieries, in which the writer has been engaged for over fourteen years. During this time, the Bell and Edison patents made the telephone a monopoly, and little was done in the way of applying it to pits. Some engineers bought telephones which were confiscated as infringements of these patents, and others rented them where they considered that the advantages of their use would pay the rental.

During the last five years, however, various methods of connecting, by speaking communication, various places in and about mines have been developed by mining engineers, both fixed and portable telephones being generally introduced, and no doubt more extensive use will be made in the future with advantage to those responsible for the safe, efficient, and economical working of collieries.

The apparatus used generally consist of (1) an electric bell to call attention, rung by a battery or magneto-electric generator; (2) an automatic switch to throw the bell out of, and the speaking part into, the circuit, and the reverse, as required; (3) a transmitter (of speech); and (4) a receiver (of speech). The transmitter and receiver form sometimes one and the same instrument, answering both purposes, technically known as a receiver, or two similar receivers, one used as transmitter, may be used for convenience, being interchangeable.

The bell may be an ordinary electric signal-bell or a smaller bell ringing from a battery by pressing a push or key, or a magneto-generator and bell. Either may be best, though for dusty, damp, and dirty places, the battery arrangement is generally preferable.

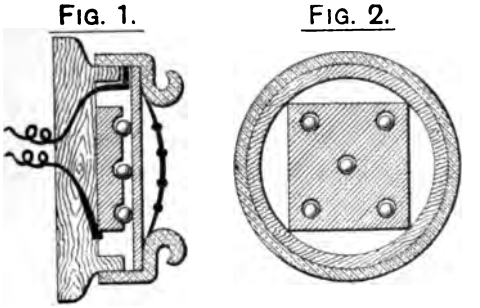
The switch is generally a lever, with a hook at one end of it, on which the receiver is hung; the weight of the receiver when on the hook puts the bell into, and the speaking portion out of, the circuit; when off, a spring (usually spiral) puts the speaking part into, and the bell out of, circuit.

The transmitter is usually a plate, board, or diaphragm held round its circumference, and connected to it is a carbon arrangement, rods, balls, and plates, or plates and granules, to vary the resistance, and thereby the current in a battery circuit. This circuit is generally a local one, part of it being the primary (and low resistance) coil of an induction-coil without an interrupter or contact-breaker, the secondary coil is in the main circuit, and the induced currents act on the receiver-diaphragm.

The receiver is generally a magnet in a case with a diaphragm and a coil of fine wire on one end. The Collier-Marr telephone is, however, rather different, the coil being placed on a separate iron core. When used as a receiver, in either case, the variations of current cause the diaphragm or diaphragms to vibrate in unison with the sound-vibrations received by the transmitter; when used as a transmitter the sound-wave vibrations cause the diaphragm or diaphragms in their rapid advances to and retrogressions from the magnet or core to induce currents capable of acting on another receiver like the variations caused by a microphone, though not generally to so great an extent. Generally, the reproduced speech is not quite so loud, although the simplicity of the magnetic telephone only makes it better than a microphone for places where no skilled electrician is employed or his services are not available to look after it.

As a microphone set for underground use, the writer prefers the Stead carbon-ball transmitter (Figs. 1 and 2); it consists of a carbon block provided with five holes, in which lie (one in each) small carbon balls, in front of which a carbon plate is placed. The induction-coil, etc., are of the usual construction.

FIG. 1. FIG. 2.



STEAD CARBON-BALL TRANSMITTER.

The Collier-Marr, double-pole Bell, or Ader receivers, are all suitable for use with or without the microphone. A special point about the

transmitter and the receivers referred to is that there are no springs, regulating-screws, or other small parts likely to become deranged.

The above form the apparatus for a station, and the lines or connexions will now be described. The lines must run between each two stations, so as to form a circuit. Several stations may be worked with the same pair of mains or lines, or one line only, and an earth, a wire-rope, or the rails of an engine-plane, may form the return, but generally two wires or a so-called metallic circuit is best: only one wire need be insulated, by being either covered wire or a bare wire fastened to insulators of earthenware or glass. When several stations are worked from one pair of mains, every station is called whenever any one is required. Each has a number, and he whose number is rung alone attends or should attend to it. The writer has fitted several of those installations in coal-mines, with as many as twelve stations upon one pair of wires, the return wire serving for engine-plane signals as well. In other cases, the ordinary haulage electric signal-wires only are used, a special number being arranged as a signal for the telephone, after which two receivers are connected by small clips at the end of cords on to the wires and conversation is carried on: the caller may be at any part of the engine-plane, and carrying the receiver—generally one Collier-Marr or one or two Ader or watch telephones.

These arrangements, however, although very good for some mines, hardly meet the requirements of others. Thus for large mines it may not be desirable to call every station to speak to one station with the chance that some station may mistake the number and so waste time. To overcome this inconvenience, any convenient station may be made an exchange station, all the lines coming separately to it, and one return wire, with branches as required, serves for all. This arrangement works very efficiently if there be always some one at the exchange station who will do his duty, otherwise much time may be wasted.

There is another system which has not, so far as the writer is aware, been tried in collieries, but which has been tried elsewhere, and he would like to submit it for the criticism of the members. It is a system by which every station can call any other station directly and separately, without the intervention of an exchange station. It is accomplished by means of a cable, containing as many separately insulated wires (braided a different colour or combination of colours for distinction) as the number of stations, plus two, one being used as a return, and the other as a spare wire in case any one fails. This cable is led to each station in turn, preferably, where practicable, completing a circuit as shown in Fig. 1. The switchboards at each station are num-

bered, say for five stations, 1, 2, 3, 4, 5 ; 2, 3, 4, 5, 1 ; 3, 4, 5, 1, 2 ; 4, 5, 1, 2, 3 ; and 5, 1, 2, 3, 4 respectively, the first number on each switch being the number of the station itself. Each station keeps its switch-lever at the first number, and when it is there any station can call that number. When the man in charge wants to call anyone else, he turns the switch to the number he wants, and calls it up. Wire 1 always goes to terminal 1, wire 2 to terminal 2, and so on everywhere. In the ideal sketch shown (Fig. 3) No. 1 station is in the head office, No. 2 is placed at No. 1 pit-bottom, No. 3 is an in-bye station, No. 4 is at No. 2 pit-bottom, and No. 5 is the lamp-room or some convenient place at the top of No. 2 shaft.

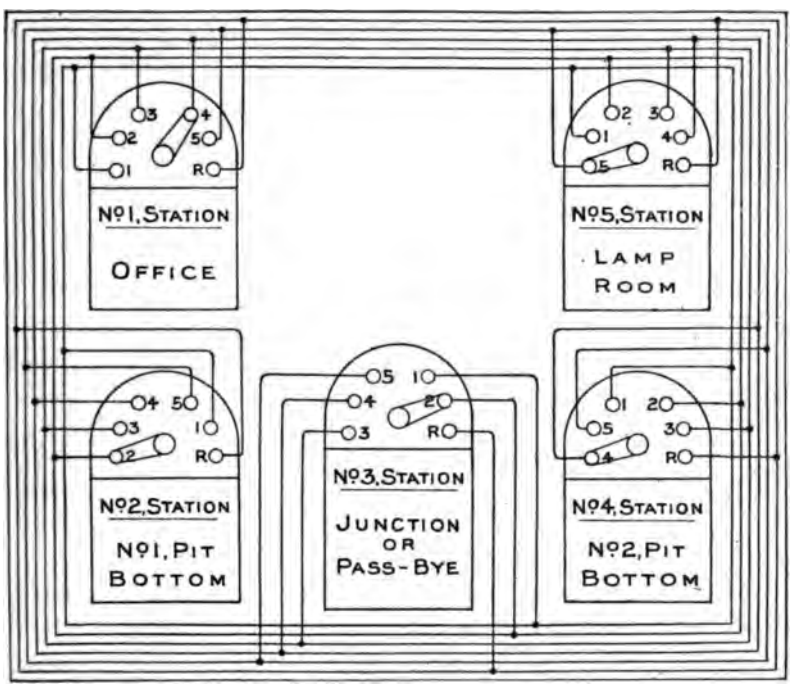


Fig. 3.—Through, separate and duplex communication between five stations; No. 1 station is calling No. 4, and No. 3 is calling No. 2.

If not very far, for the convenience of having two mains in case of any accidental interruption, the cable may pass from No. 5 to No. 1 station. Such an arrangement would (with probably more in-bye stations) be of great service in ordinary working, and might be invaluable in that often unreckoned for but lamentably possible occurrence an explosion of fire-damp, as one way might remain good with the other ruptured or destroyed.

Mr. H. B. NASH (Clarke's Old Silkstone colliery) said that he supposed the system described by Mr. Bennett would necessitate the use of a great multiplicity of wires ?

Mr. BENNETT said that he suggested the use of a number of insulated wires braided into one cable.

Mr. NASH asked whether the cable would be destroyed in case of an explosion ?

Mr. BENNETT replied that, if one circuit was destroyed, the other one would be available. If one cable from a telephone-station was intact, it would be as useful as if both were intact.

Mr. C. E. RHODES said that there need be no waste of time if each station was signalled to by a different number of strokes on the call-bell. With a central exchange at the pit-bottom, any number of stations could be communicated with, and by connecting this exchange at the pit-bottom with the office on the surface, communication could be made with any part of the pit, however large. He had found this arrangement to be most convenient.

Mr. BENNETT presumed that Mr. Rhodes had always somebody at the pit-bottom ; but everyone might not be so fortunate in that respect.

Mr. RHODES said there was no reason why the surface office should not be in communication with all of the underground stations.

Mr. BENNETT said in that case all the branch wires would have to pass up the shaft.

The PRESIDENT said that wires were not so liable to injury in the shaft as on the underground roads.

Mr. RHODES said that there was only a single wire up the shaft, and 12 miles of cable were in use.

Mr. BENNETT said that by his proposed plan one would be able to call up any telephone station without having to call the attendant at the central exchange. The idea was to do away with the exchange, which possessed no advantage.

Mr. RHODES said that the use of the telephone must grow in collieries, and in case of accident it was most convenient.

Mr. THIRKELL moved a vote of thanks to Mr. Bennett for his paper.

Mr. NASH seconded the motion, which was agreed to.

The meeting then closed.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,
HELD IN THE ODDFELLOWS' HALL, KILMARNOCK, DECEMBER 7TH, 1895.

MR. H. M. CADELL, VICE-PRESIDENT AND AFTERWARDS MR. GEO. A. MITCHELL, PRESIDENT, IN THE CHAIR.

The minutes of the General and Special Meetings of October 9th were read and confirmed.

The following gentlemen were elected :—

FEDERATED MEMBERS—

Mr. CHARLES F. ALSTON, Pilgrim's Rest, South African Republic.
Mr. THOS. LOCHHEAD HORNE, Twechar Works, Kilsyth.
Mr. JOSEPH PARKER, Montgomery Street, Larkhall.

DISCUSSION ON MR. ROBERT FISHER'S "NOTES ON MINING IN PORTUGAL."*

The SECRETARY said they were indebted to Mr. Fisher for having given these notes on a country which was not much in evidence as regards mining. There was one rather peculiar arrangement of strata which was referred to by Mr. Fisher, and also shown in Fig. 2 (Plate III.), viz., the vein of coal dipping almost at right angles to the other seams lying above it. He should like to know if Mr. Fisher saw that vein exposed, and could explain whether it could really be said to be persistent through the strata to any great extent. He would be disposed to think it a mere bending of the seam on a slip, and to believe that it would not persist through the strata. Mr. Fisher also referred to the coal being in little demand for household purposes, on account of the warmth of the climate. At the same time, he said that there was a great demand for the small branches of trees. This seemed to argue that if a supply of coal were forthcoming, a demand would arise.

The PRESIDENT moved a vote of thanks to Mr. Fisher for his paper, which was heartily accorded.

* *Trans. Fed. Inst.*, vol. x., page 121.

THE SOUTHERN AYRSHIRE COAL-FIELDS.

By ROBERT W. DRON.

The portion of the Ayrshire coal-field dealt with in this paper is the district south of the Kilmarnock and Irvine coal-fields. From the point of view of both the geologist and the mining engineer this part of Ayrshire exhibits many points of interest. In describing this coal-field it is necessary to explain the general geological structure before taking up the details of the various districts. By a reference to the geological map (Fig. 1, Plate XII.) and the horizontal section (Fig. 2, Plate XII.) it will be seen that the formation generally is that of a basin having its centre near Mauchline, and the outcrops of the various divisions of the strata occur in a fairly regular series of concentric lines round about this point.

The central portion of the basin consists of a well-defined series of Permian or New Red Sandstone rocks. Surrounding this area, there appears at the surface a ring of volcanic rocks, which also belong to the Permian series. These volcanic rocks are composed chiefly of trap, tuff, and ash which have been thrown from the many volcanoes active during the early Permian period. Large numbers of the necks, or craters, of those volcanoes are found scattered throughout the district, principally towards the south, at Dalmellington and New Cumnock. A very good section of these volcanic ashes is exposed in the bed of the river Ayr, near the Ballochmyle viaduct of the Glasgow and South-Western Railway. Immediately underlying those rocks are the red sandstones of the Carboniferous series.

The Carboniferous series in Ayrshire, as in other parts of the country, may be divided into four groups :—

I. Coal-measures	{	Red Sandstone rocks. Upper Coal-seams. Lower Coal-seams.
II. Millstone Grit.		
III. Carboniferous Limestone ...	{	Upper Limestones. Coal-seams. Lower Limestones.
IV. Calciferous Sandstone.		

Coal-measures.—In the Coal-measures there are two indices which are found with considerable regularity throughout the county, and which may be used to indicate the horizon of the different coal-seams. These are the black-band ironstone and the clay-band ironstone. The black-band ironstone lies at the base of the series, and occupies a position similar to that of the slaty-band ironstones of Lanarkshire. The seams between the black-band and clay-band ironstones correspond with the lower seams (Drumgrays) of the Lanarkshire coal-field. The seams above the clay-band ironstone correspond in the same way with the upper seams of the Lanarkshire coal-field, the ell and main coal-seams of Ayrshire being probably in the same horizon as the ell and main coal-seams of the Hamilton district.

Plate XIII. contains several vertical sections of the seams found in the various districts. The probable relation between the seams of each district is indicated by dotted lines, but of course this relation is in many cases merely suggestive, as it is almost impossible to establish an absolute correspondence.

Millstone Grit.—The Millstone Grit is not so regular in Ayrshire as in some other parts of the country. At Muirkirk, it attains a thickness of 720 feet. At the western side of the basin, its position is not at all clearly defined, and the base of the Coal-measures appears in many cases to rest directly on the Carboniferous Limestone.

Carboniferous Limestone.—The Carboniferous Limestone Series also attains its greatest thickness in the vicinity of Muirkirk and Glenbuck. On the western side of the basin it is generally much thinner. In fact, at some places, the Coal-measures seem to rest directly on the Calciferous Sandstone Series.

There are two groups of Limestone seams, the upper group corresponding with the Arden and Index Limestones, and the lower group with the Hosie and Hurlet Limestones of Lanarkshire. These limestones form an excellent geological index, as they can easily be identified by their fossils and their physical properties. As shown in Plate XIII. the coal-seams mostly lie between the two groups of limestone.

Calciferous Sandstone.—The Calciferous Sandstone Series does not attain a great thickness in this district. As yet, it has not been found to contain any of the seams of shale and coal which make it so valuable in Midlothian. There are a few seams of an impure dolomitic limestone (known as cornstones), and these have been worked for agricultural purposes. There are also deposits of good building-stone.

Igneous Rocks.—The occurrence of intrusive igneous rocks is a well-known feature of the Ayrshire coal-field. These igneous rocks are

divided into three distinct classes, according to their geological age. First, there are bands of basaltic rocks (dolerite), both intrusive and interbedded, known as "floating whins." The majority of these whins have been injected at some time after the formation of the Coal-measures, and in many cases they take the place of the coal-seams over large areas. Where they appear at the surface, they frequently form very prominent features of the landscape; for instance, near Dalmellington, where the terraced hills of Benbeoch and Benwhat are formed by the wearing away of the softer rocks surrounding the basalt. In most cases where basalt appears at the surface, it does not extend vertically downward for a great depth, and its presence at the surface does not necessarily affect the underlying coal-seams.

To the next class belong the volcanic necks, or craters, previously mentioned. The following description of these volcanic masses is given in the Memoirs of the Geological Survey, Scotland:—

> Outside the Permian basin the Coal-measures are pierced by numerous more or less circular masses of a coarse unstratified agglomerate. These come up as huge columns or pipes through the Coal-measures, and appear at the surface usually as small rounded hillocks or hills. The coal-seams have been worked round and up to them, and have sometimes been found to show the alteration which is usually visible near igneous rocks. . . . There can be little doubt that in these columns or "necks" we see part of the vents through which volcanic material was ejected in Permian times.*

In the neighbourhood of Dalmellington there are about 20 of these old volcanoes. There are several in the New Cumnock district, and they are found even as far south as Sanquhar. There are good examples at Sorn Hill, near Catrine, and at Raith Hill, near Coylton.

In the third class of igneous rocks we reckon the intrusive dykes of dolerite. These dykes are found running in almost a straight line from north-east to south-west, and cut through all the Carboniferous rocks and floating whins. They are also found at places penetrating the overlying Permian rocks. This circumstance shows that they have been injected long after the formation of the Coal-measures. As found in the underground workings, they vary in thickness from a foot or two up to 40 or 60 feet. In most cases they cut clean through the coal-seams, burning it for 1 or 2 feet on each side. Occasionally, however, the intrusive matter occupies the position of the seam over a small area, and in that case the dolerite is sometimes changed from its usual hard, crystalline texture into a soft rock, known as "white trap."

Some details regarding the various districts are now given.

* *Explanation of Sheet 14, Ayrshire: Southern District*, page 22.

Muirkirk and Glenbuck.

The Muirkirk and Glenbuck coal-field takes the form of a trough, extending from Glenbuck to a point about 2 miles west of Muirkirk, a distance of 7 miles.

The width of the trough at Glenbuck is about 1 mile, but towards the west it becomes about 2 miles wide. The Millstone Grit is found in the centre of the trough, and the Carboniferous Limestone coal-seams are found cropping out on each side at an inclination of 20 to 30 degs. In some cases the pits are sunk through the Millstone Grit. There are numerous faults running through this coal-field, generally running at right-angles to the line of strike. There is also a series of igneous dykes running generally from south-east to north-west. There are a number of "floating whins" which frequently occupy the position of the coal-seams, and become converted into "white trap."

Most of the coal-seams in this district that are being worked are from the Carboniferous Limestone Series and the section of the seams is given in Plate XIII.

The common coal is of a splinty nature, suitable for furnace purposes. The most valuable feature is the occurrence of cannel coal along with the seams of common coal. It is principally in the three feet and nine feet seams that this occurs, and the following sections show the position and thickness:—

Three Feet Seam.	Ft.	Ins.
Coal	1	3
Grey fakes	0	8
Horny (inferior gas coal) ...	0	4
Coal	1	8
Gas coal	0	5
Coal	1	0
Daugh	0	2

Nine Feet Seam.	Ft.	Ins.
Head coal	1	6
Coal	0	4
Gas coal	0	11
Coal	0	6
Fireclay	0	1½
Coal	1	4
Fireclay	0	2
Coal	1	4

Occasionally a little gas-coal is found in the six feet or Catchieburn coal-seam. At Glenbuck, a seam of very rich Boghead gas-coal, 7 inches thick, and lying 36 feet above the three feet coal-seam, has also been worked. These cannel coals yield from 11,000 to 12,000 cubic feet of gas per ton, with an illuminating power of about 33 candles.

Like most cannel coals, they are liable to considerable variation in thickness, and towards Muirkirk they become a little thinner. The McDonald coal-seam at Muirkirk is so sulphury and dirty as to be unworkable.

To the east and south of Muirkirk, the nine feet, three feet, and fo[illegible]r feet coal-seams are becoming exhausted. There is a considerable area [illegible]f the other seams still to work, but as they do not contain the cannel co[illegible]l they are not so valuable. West of Muirkirk, there is an area along t[illegible]e north bank of the river Ayr which has not yet been developed.

At Wellwood, about 2 miles west of Muirkirk, the Coal-measures a[illegible]n found occupying the centre of the trough. A section of the coals fou[illegible]n in the Wellwood basin is shown in Plate XIII.

Mauchline and Sorn District.

The Carboniferous Limestone-measures are again found at a poi[illegible] about 3 miles east of the village of Sorn. This area of limeston[illegible] measures stretches on both sides of the river Ayr for about 3 miles.

On the south, it is bounded by a large downthrow fault, whic[illegible] throws in the Coal-measures of the Lugar coal-field. Towards t[illegible] west, it is overlain by the upper sandstones of the Coal-measures, an[illegible] probably there is a large fault between Sorn and Catrine. There also a northerly extension of this coal-field over the Grange Mui[illegible] Coal-seams, ironstone, and limestone have been worked in the Carbon[illegible]ferous Limestone Series, in the Sorn district, during the last hundr[illegible] years. A pit on the southern bank of the river Ayr was working th[illegible] following section in the year 1797 :—

> The main seam is about 8 feet thick, with 6 inches of fireclay in the midd[illegible] Immediately above this seam, there is a stratum of the same kind of clay 18 inch[illegible] thick; above this [comes] 18 inches of coal, then 20 inches of hard black slate, a[illegible] over that near 3 feet of coarse coal.*

That is 12 feet of coal and 3 feet 8 inches of dirt.

Operations have also been carried on towards the north at Gran[illegible] Muir. It is said that a seam of coal 5 feet thick was worked here [illegible] one time only a few feet from the surface.†

The most recent working was for splint and gas-coal, at a small p[illegible] about ½ mile north of Sorn village. The coal-seams worked seemed r[illegible] correspond with those found on the southern bank of the river Ayr. Th[illegible] were only a few feet below the Upper Limestone, so that they also cor[illegible] spond to the top coal-seams of the Muirkirk section. The gas-coal w[illegible] found in a position corresponding with the 7 inches of Boghead gas-co[illegible] referred to at Glenbuck. The thickness, of course, was variable, but t[illegible]h average seems to have been about 14 inches.

The workings were only of limited extent, as all the output w[illegible]as carted for a long distance, and until they have been opened up o[illegible] a

* *Statistical Account of Scotland* (1798), vol. xx., page 153. † *Ibid.*

larger scale it is not possible to arrive at a very definite estimate of the stratigraphical position. Coal-seams have also been worked in the upper measures between Sorn and Catrine, but only to a limited extent.

Both Coal and Limestone-measures thin out to the north-west. North of Mauchline, the coal-seams are considered as unworkable. North-west of Mauchline, there is more hope of workable coal yet being found. At Adamhill, about 4½ miles north-west of Mauchline, two coal-seams have been worked, a gas-coal and a house-coal 42 inches thick: this is in the Upper Coal-measures. No workable seam has been found in the Limestone-measures at this edge of the basin. Of course, both the Coal and Limestone-measures underlie the New Red Sandstone at Mauchline; but it is impossible to say at what depth and in what condition the seams may be found.

Symington and Dundonald District.

Very little can be said about the coal-seams in this district. There is little doubt that the Coal-measures are present, but they are very much disturbed by intrusive igneous rocks. In the neighbourhood of Dundonald, coal-seams have been found underlying the basalt. It is quite probable that considerable areas of workable coal may yet be found between Dundonald and Symington and southwards towards Ayr. In the vicinity of Ayr, the coal-seams are practically unworkable on account of the intrusive igneous rocks, and the result of trial-borings along the coast between Ayr and Troon would seem to indicate that there is very little chance of finding workable coal between Ayr and Irvine.

Annbank, Cumnock, and Lugar Coal-fields.

Sections at Annbank and at Lugar are given in Plate XIII. In the Lugar district, the principal mineral worked for a long time was the black-band ironstone, but on account of the introduction of Spanish iron-ore this working has been abandoned. The best seams about Cumnock are the ell and main coal-seams, but these two seams are rapidly becoming exhausted, and attention is being turned to the lower seams. The maid coal-seam is of fairly good quality, but the seams below are thin and irregular. The position of some seams is shown on the section between the low maid coal and the black-band ironstone. Bores put down through this position give very conflicting results, so that the position shown on the section is not to be taken as absolutely correct. The purpose of the writer will have been served if he indicates that such

seams are there, and that these seams may sometimes attain a workable thickness. These lower coal-seams correspond with the lower seams (Drumgrays, etc.) of the Lanarkshire section.

In this part of the coal-field, there is less disturbance from igneous rocks than in most parts of Ayrshire. There are a few floating whins, notably one near Cumnock, which destroys the ell coal-seam over a considerable area. Farther west, however, the action of the igneous rocks is more intense, and in the Coylton and Annbank districts very large areas of all the seams have been destroyed by floating whins and volcanic eruptions. Farther west still, between Annbank and the coast, the coal-seams become unworkable on account of this whin.

In the Annbank district, the upper seams have been very extensively worked, and attention is also being paid to the lower seams. These seams are somewhat better here than at Cumnock. Some attempt has been made to connect them with the Kilwinning section. The Kilwinning ell and the Kilwinning main coal-seams are frequently found of workable thickness, but the Ladyha' coal-seam is generally very poor.

New Cumnock and Dalmellington Coal-field.

A section of the coals which are being worked at New Cumnock and Dalmellington is shown in Plate XIII. The upper and lower gas coal-seams of New Cumnock correspond with the Sillyhole and Chalmerston coal-seams of Dalmellington.

These upper seams of New Cumnock are of great value on account of the cannel coal which is associated with them. The following are average sections of these seams :—

Upper Gas Coal.	Ft.	In.
Gas coal, heads	1	0
Gas coal, breasts	3	0
Common coal	2	0

Lower Gas Coal.	Ft.	In.
Gas coal	1	0
Common coal...	5	0

The gas coal yields over 10,800 cubic feet of gas per ton, with an illuminating-power of 29 candles. There is another cannel coal, 23 inches thick, lying between the upper and lower gas coal-seams. This seam has been little worked, but it has been passed through at several points and the quality found good. All the other seams shown in the section have been worked more or less. The common coal of the lower gas coal-seam is of exceptionally good quality.

The New Cumnock coal-field is divided into two distinct portions by a great fault running along the valley of the river Nith. Workings have been carried on for many years to the south of this fault. The

general direction of dip is towards the north, and as the inclination averages 1 in 5 the seams attain a depth in the vicinity of the fault of over 1,200 feet. To the north, or shallow side, of the fault the line of *dip* alters. Generally speaking, the strata dip towards the south, but the inclination is very moderate. Although many of the coal-seams are found within a few feet of the surface, they are not at present being wrought, except by one small pit, for want of railway connexion. There are, however, a considerable number of old pits and mines, which at one time worked the coal for cart-sale. This coal-field stretches right across to Dalmellington, and any coal-seams which have been worked appear to correspond rather with the Dalmellington section than with the seams found to the south of the New Cumnock fault. Overlying the coal-seams of the New Cumnock district, there is a bed of whin, about 30 or 40 feet thick, about 36 feet above the upper gas coal-seam. With the exception of a small area near the outcrop, the coal-seams are hardly ever affected by this whin. There are also a number of intrusive dykes running generally from east to west. A few of the Permian volcanoes already referred to are found in this district.

At one part of the field (Craigman), the overlying whin has had a peculiar effect on a seam of coal. The whin comes down very close to the top of the seam, and the heat has caused a layer of pure graphite or plumbago to be formed on the top of the coal. About 100 years ago this graphite was worked to some extent, and the workings are still open. The black-band ironstone is only a few inches thick in the New Cumnock district, but towards Dalmellington it becomes of greater thickness and of excellent quality. The coal-seams lying between the black-band and the mussel-band (Plate XIII.) are being worked at various points between New Cumnock and Dalmellington. The action of the whin on some of these seams has transformed them into very valuable smithy coals. There is a large area of unexplored Coal-measures on the high ground to the north of this coal-field, and very little is known as to the actual condition of any coals which may be present.

The principal mineral of the Dalmellington coal-field is the Burnfoot black-band ironstone. This ironstone is being extensively worked and smelted. Nearly all the coal-seams shown in the section have been worked at various parts of the district. In this district there are about twenty of the Permian volcanic necks already referred to. Large tracts of the surface are covered with sheets of whin, and in very many cases the pits have been sunk through this whin, and the ironstone worked below.

Carboniferous Limestone Series of Dalmellington and Cum

To the north-east of New Cumnock, there is a considerable area Carboniferous Limestone Series stretching northwards to the Mu branch of the Glasgow and South-Western Railway. Coal-seams been worked in this area at two places, viz., Gass Water, at the and Guelt and Edgehill, near New Cumnock. It is about thirty since these coal-seams were worked.

Section at Edgehill.*

	Thickness of Strata. Ft.	Ins.		T o
Clay gas coal	1	8	Strata	
Strata	10	0	Twelve-feet coal	
Nine-feet coal	9	0	Strata	
Strata	16	0	Three-feet coal	
Eleven-feet coal	11	0		

Section at Gass Water.†

	Thickness of Strata. Ft.	Ins.		T o
Limestone	6	0	Strata	
Strata	19	6	Coal	
Limestone	1	6	Strata	
Strata	12	0	Coal	
Limestone	5	0	Strata	
Strata	12	0	Smithy coal	
Coal	2	6	Strata	
Strata	2	2	Clay ironstone	
Coal	2	4	Strata	
Stone	0	10	Coal	
Coal	0	9	Strata with ironstone ...	
Stone	0	9	Coal	
Coal	3	0	Strata	
Stone	0	6	Limestone	
Coal	1	3		

South-east of New Cumnock the coals of the Carboniferous stone Series thin out, and although bore-holes have been put through their position, no workable coal-seams have been found. or two places are also shown on the map (Fig. 1, Plate XII.) whe Limestone-measures are found cropping to the surface between Cumnock and Dalmellington.

No coal-seams of workable thickness have been found at points, and an examination of the strata, as exposed in stream cuttings, would lead one to believe that this southern margin of th field was the shore of the great lake in which the Coal-measure deposited. As shown on the map (Fig. 1, Plate XII.), the Coal-m come into direct contact with the Silurian rocks. A little to the nort

* *Memoirs of the Geological Survey, Scotland, Explanation of Sheet* 15, *Ayrshire: South-East Part*, page 25. † *Ibid.*, page 29.

of New Cumnock, the Upper Limestone was worked (at Benston) and was lying quite regular. Nothing can be said, however, regarding the underlying coal-seams, as no bore-holes have been put down deep enough.

On the western edge of the coal-field (at Patna), coal-seams are being worked in the Carboniferous Limestone Series. The seams here are so close together that they are worked as one seam, and the thickness of coal is about 15 feet. A section and description of the working was given in a paper communicated to the Mining Institute of Scotland by Mr. David Smith.* It is estimated that the distance from the black-band ironstone at Dalmellington to the Patna coal-seam is about 1,200 feet.

It is an interesting question whether the coal-seams of the Carboniferous Limestone Series will be found at a workable depth below the Coal-measures of the Cumnock and Dalmellington coal-field.

As already remarked, the Millstone Grit is generally very thin in South Ayrshire. At Wellwood, the distance from the black-band ironstone to the first coal-seam of the Limestone Series is 1,332 feet. Over a large area of the New Cumnock and Dalmellington coal-field, the black-band ironstone is found very near the surface: so that taking the full thickness as found at Dalmellington and Muirkirk, the depth to the first coal-seam of the Limestone-measures should only be from 1,200 to 1,560 feet. If proprietors and other persons interested would combine to put down one or two deep bore-holes it is almost certain that the position of the coal-seams would be found at what must soon be considered a workable depth.

Girvan Coal-field.

There is a detached area of the Limestone-measures forming a small trough along the banks of the river Girvan. The length of this trough is about 3½ miles, the breadth about ½ mile, and the coal-seams are found cropping out on each side. From 30 to 40 feet of workable coal-seams are found in this section, all in a space of less than 180 feet. The quality of the coal is not very good, the seams being generally of a hard, splinty nature. A section of this coal-field is given in the *Memoirs of the Geological Survey, Scotland.*†

The average annual output of coal from Ayrshire during the last five years has been 3,663,290 tons. Various estimates have been made as to the quantity of coal still remaining to work. A Royal Commission was appointed in 1866 to enquire into the amount of workable coal in

* *Trans.*, vol. xiv., page 113.

† *Explanation of Sheet* 14, *Ayrshire: Southern District*, page 16.

Great Britain. After an exhaustive enquiry, extending over five years, they issued a report, in which it was stated that in Ayrshire there were still available a quantity of 1,785,397,098 tons. Allowing for an annual output of three million tons and an additional one million tons per annum for coal left in as barriers or lost in the workings, the total quantity worked since 1866 would be 116 million tons. If the estimate of the Royal Commission be correct, the quantity now unworked must be 1,669,000,000 tons. One frequently hears it said that the Ayrshire coal-field is becoming exhausted, but, according to the above figures, there is sufficient coal to maintain double the present output for about 170 years.

It is an acknowledged fact that the best seams of the Lanarkshire coal-field are rapidly becoming exhausted. In a paper read by Mr. Robert Thos. Moore in 1893, before the Philosophical Society of Glasgow, it was shown that the upper coal-seams of the Clydesdale district would be exhausted in twenty-four years.* If, therefore, the output of Scotland is to be maintained and increased, Ayrshire will soon require to contribute a very much larger proportion than it is now doing. No great increase can be expected from the existing pits, and the time is fully ripe for the opening up of the undeveloped fields. There is no district in Scotland which contains such large unproductive areas as this part of Ayrshire. If these resources are developed on a comprehensive and liberal scale, Ayrshire may even become in the near future as great a coal-producing county as Lanarkshire. Certainly, it is a matter of national importance that nothing be allowed to stand in the way of the opening up of these districts by whatever methods will best serve the interests of the whole country.

The discussion was adjourned.

The following paper by Mr. H. M. Cadell on "Gold-mining in the Hauraki District, New Zealand," was taken as read:—

* *Proceedings*, 1892-93, vol. xxiv., page 60.

GEOLOGICAL MAP

OF

THERN AYRSHIRE.

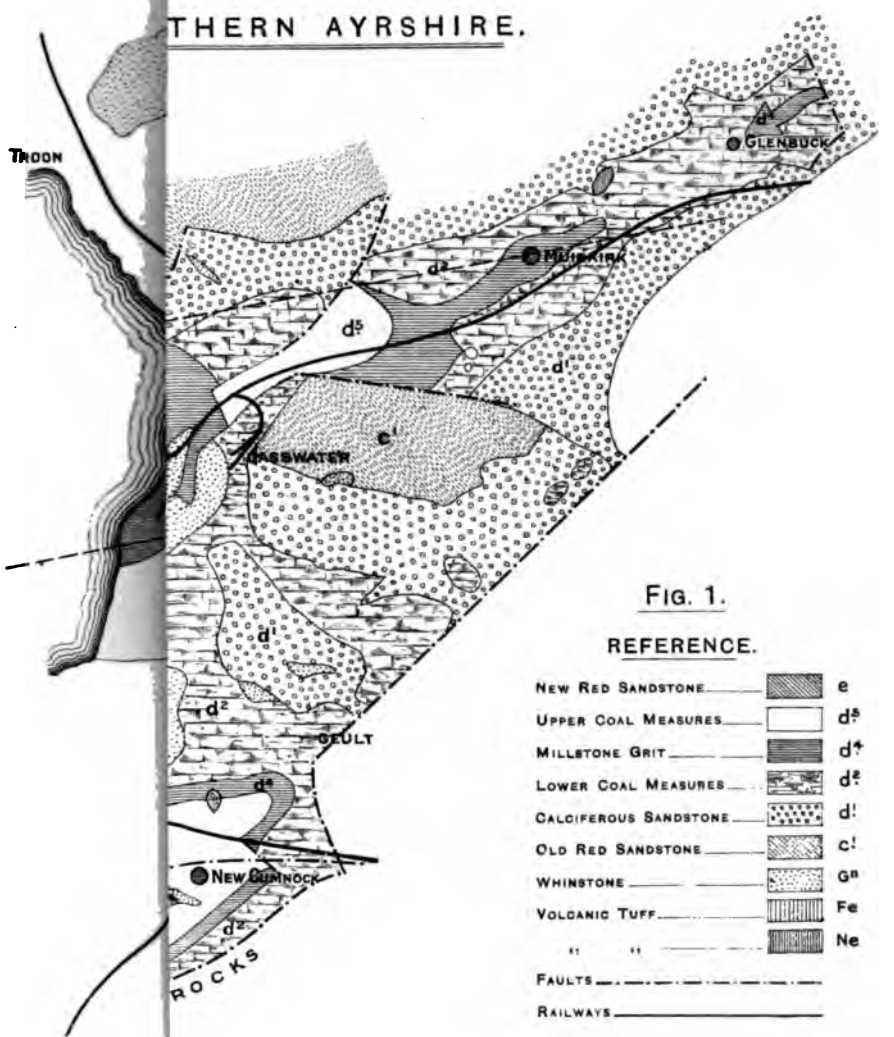
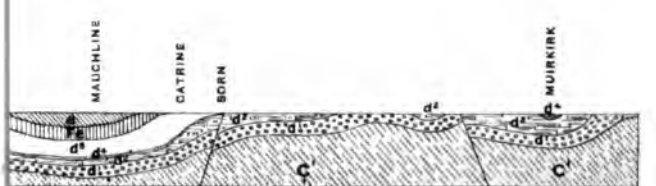


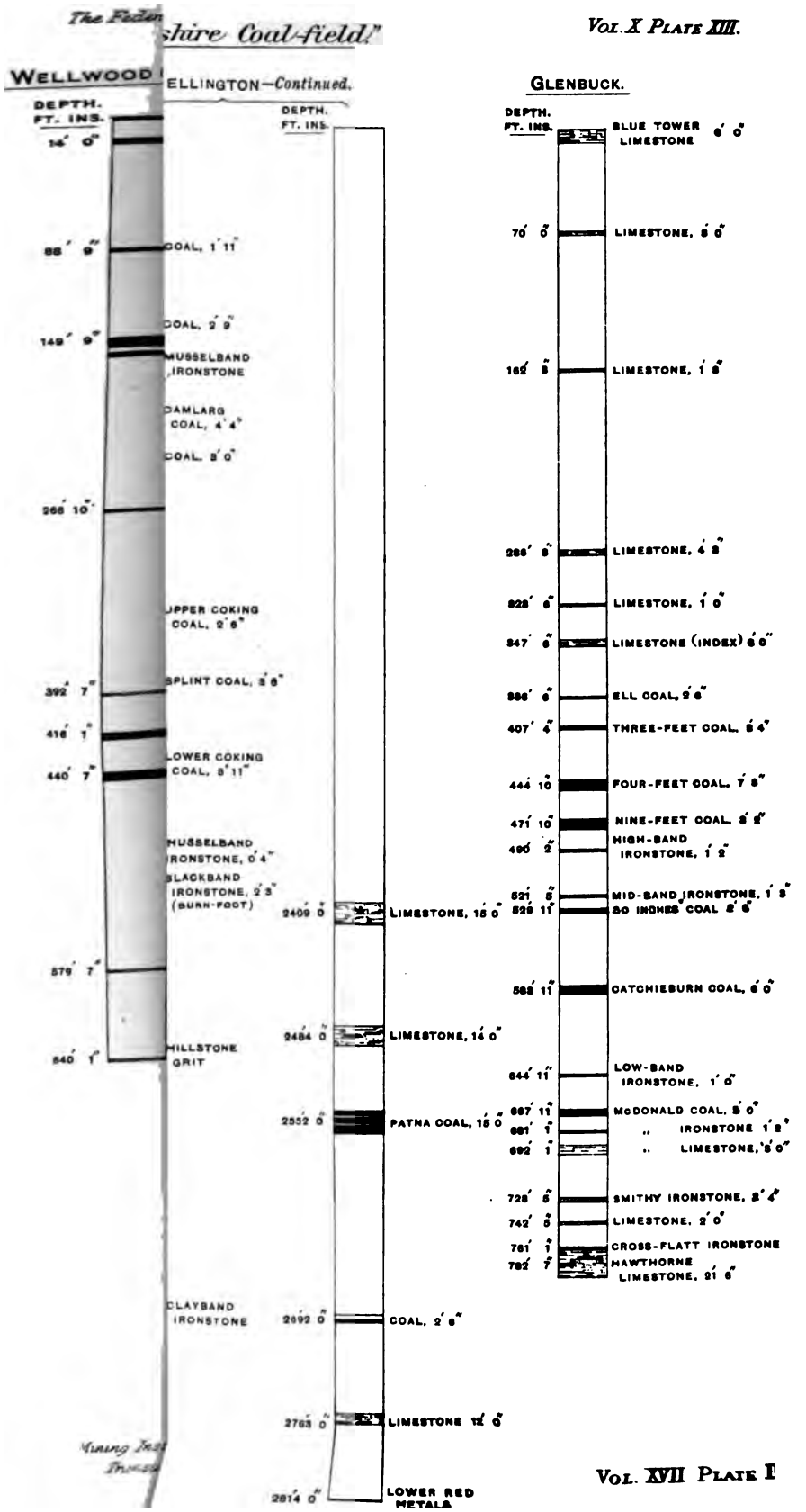
FIG. 1.

REFERENCE.

New Red Sandstone	e
Upper Coal Measures	d^5
Millstone Grit	d^4
Lower Coal Measures	d^2
Calciferous Sandstone	d^1
Old Red Sandstone	c^1
Whinstone	G^n
Volcanic Tuff	Fe
" "	Ne
Faults	
Railways	



CTION FROM AYR TO MUIRKIRK ON LINE A B OF FIG. 1.


The Fifeshire Coal-field.
WELLWOOD
ELLINGTON—Continued.
DEPTH. FT. INS.
14' 0"
88' 9"
COAL, 1' 11"
149' 9"
COAL, 2' 9"
MUSSELBAND IRONSTONE
CAMLARG COAL, 4' 4"
COAL, 3' 0"
266' 10"
UPPER COKING COAL, 2' 6"
392' 7"
SPLINT COAL, 2' 8"
416' 1"
LOWER COKING COAL, 3' 11"
440' 7"
MUSSELBAND IRONSTONE, 0' 4"
BLACKBAND IRONSTONE, 2' 3" (BURN-FOOT)
579' 7"
HILLSTONE GRIT
640' 1"
CLAYBAND IRONSTONE
DEPTH. FT. INS.
2409' 0" LIMESTONE, 15' 0"
2484' 0" LIMESTONE, 14' 0"
2552' 0" PATNA COAL, 15' 0"
2692' 0" COAL, 2' 6"
2763' 0" LIMESTONE 12' 0"
2814' 0" LOWER RED METALS
GLENBUCK.
DEPTH. FT. INS.
BLUE TOWER LIMESTONE 6' 0"
70' 0" LIMESTONE, 5' 0"
152' 3" LIMESTONE, 1' 8"
288' 8" LIMESTONE, 4' 8"
328' 6" LIMESTONE, 1' 0"
347' 6" LIMESTONE (INDEX) 6' 0"
386' 6" ELL COAL, 2' 6"
407' 4" THREE-FEET COAL, 5' 4"
444' 10" FOUR-FEET COAL, 7' 8"
471' 10" NINE-FEET COAL, 5' 2"
490' 2" HIGH-BAND IRONSTONE, 1' 2"
521' 5" MID-BAND IRONSTONE, 1' 3"
529' 11" 30 INCHES COAL 2' 6"
568' 11" CATCHIEBURN COAL, 6' 0"
644' 11" LOW-BAND IRONSTONE, 1' 0"
667' 11" McDONALD COAL, 5' 0"
681' 1" " IRONSTONE 1' 2"
692' 1" " LIMESTONE, 5' 0"
728' 5" SMITHY IRONSTONE, 2' 4"
742' 5" LIMESTONE, 2' 0"
761' 1" CROSS-FLATT IRONSTONE
762' 7" HAWTHORNE LIMESTONE, 21' 6"

GOLD-MINING IN THE HAURAKI DISTRICT, NEW ZEALAND.

By HENRY M. CADELL, B.Sc., F.R.S.E., F.G.S., Vice-President, Mining Institute of Scotland.

Introduction.

On the way home from Western Australia in September, 1895, the writer visited several mines in the well known gold-fields of Ballarat and Bendigo, in Victoria, and by way of comparing the Australian with the New Zealand gold mines, halted at Auckland, and spent some time in visiting some of the most notable gold-fields of the North Island. The boom in gold-mining had recently extended to this part of the Empire, and the local share-market was in a state of great activity. The writer was anxious before returning home to ascertain whether or not there was any solid foundation for this excitement, and whether the mines, which had hitherto, with a few exceptions, been languishing more or less, were likely, with the help of British capital, to again prove remunerative. He was much pleased with the result of these investigations, and will now endeavour to briefly describe the district, its geological features, mining history, and future prospects, in the hope that his observations may be the means of drawing the attention of the mining public at home to one of the most interesting auriferous regions in Australasia.*

For the statistics and detailed descriptions of the Hauraki mines, the writer has verified the information obtained at the mines by referring to the *Reports* for the years ending March 31st, 1894, and 1895 respectively. He has also gleaned much useful information from the *Handbook of New Zealand Mining*, published in 1887, and from recently published local maps and other sources which are practically inaccessible to the public at home.

* The Hauraki mines have been already described in the earlier volumes of the *Transactions* of the Federated Institution of Mining Engineers, but so great have been the developments of the last two years in this and other gold-fields that any description soon becomes antiquated unless regularly brought up to date. In this paper the writer has not only endeavoured to bring the statistics up to date, but has dealt much more fully with some interesting parts of the subject than has been done by the authors of previous communications.

Geographical Features.

The Hauraki gold-mining district in the North Island forms a long strip of high and mountainous country, bounded on the east by the sea and on the west by the valley of the Waihou or Thames river, and its seaward prolongation the Firth of Thames and Hauraki Gulf (Plate XV.). The width of the auriferous area varies from 10 to 20 miles, and gold has been found at intervals over its whole extent, from Te Puke in the south to the neighbourhood of Cape Colville, a distance of over 100 miles, while the Great Barrier Island, which is geologically part of the Hauraki ridge, has lately been found to be auriferous also. The Hauraki peninsula rises steeply from the sea to the crest of the Colville Range, which forms the main watershed for the streams on each side. The highest summit at the northern extremity is Moehau, west of Port Charles (2,800 feet), and the highest point of the range is the Te Aroha mountain, which rises steeply behind the Te Aroha township to a height of 3,126 feet above sea level. The upper parts of the range are clad with a dense growth of the magnificent kauri pine, some of whose stems are over 12 feet in diameter at the base, also the climbing rata vine, gorgeous tree-ferns, acacias, palms, and other semi-tropical plants. The lower slopes are thickly covered with brackens and ti-tree bushes, which grow up rapidly to a height of 6 to 10 feet, and swathe the country for miles in a bosky russet green mantle, just as our own hills are clothed in their brown robe of heather. The rainfall in the district is plentiful, and the side gorges are the seat of perennial streams that dash swiftly down through the damp forest glades, and provide abundant water-power for mining or other machinery along their courses.

Geology.

The evidences of very recent volcanic action are but too prominent in this part of New Zealand, and it is only a little over nine years since the great eruption of Mount Tarawera warned the inhabitants of the island that the hidden fires are not yet extinct. Hot springs issue from the base of the Te Aroha mountain, and are used for baths at the pretty little sanatorium there. Farther south, the geysers, hot springs and mud-volcanoes at Rotorua and Taupo afford a constant attraction to sightseers from all parts of the world. The destruction in 1886 of the magnificent and world-renowned White and Pink Terraces at the base of Tarawera has, it is true, deprived visitors of one of the most beautiful evidences of

ecent thermal action, but the terrible effects of the outburst show far ore impressively the nearness and power of the subterranean fires that smothered beneath the surface.

These traces of recent thermal energy are, however, fortunately for ning enterprise, for the most part beyond the limits of the Hauraki l-fields, and the hot springs of Te Aroha are the only evidences of terranean heat in the immediate vicinity of the auriferous area. The s of the peninsula are nearly all volcanic, with the exception of a interstratified beds and local patches of slate that crop up from be- and show the nature of the platform or old land-surface on which volcanic materials were laid down.

Mr. James Park, F.G.S., director of the Thames Mining School, read, July 2nd, 1894, before the Auckland Institute, an important paper the Geology of the Thames gold-field, and this work supplies h valuable information about the rocks of the district. During whole of the Secondary epoch the Hauraki area appears to have been pied by a deep, still sea devoid of islands and undisturbed by anic eruptions. But at the close of the Cretaceous period the in this area began to emerge gradually from the sea, and an nd of large size appeared to the north-east of the present site of Omandel. The ever active agencies of denudation began to wear y the dry land, and the spoil was carried to the sea by numerous ams and rivers. After a period of rest, the land began to sink, and peaty deposits which had accumulated on the low-lying marshy shores the island were soon submerged, and in their turn became covered a coarse gravels, sands, and clays, carried seawards by the streams ch descended to the coast-line. The land still continued to sink, and he sea encroached true marine deposits were formed above the fluvia- materials, and, as shelly limestones, closed the sequence of the coal- sures and marked the complete submergence of the dry land. After , however, there came a time when the quietude of the ancient ondary ocean was rudely disturbed. Great fissure-rents opened in the an-floor and vast submarine eruptions poured out floods of lava on newly formed strata. These accumulated until many of the volcanoes ed their heads above the water. This vast outburst took place in ver Eocene times, as is proved by a bed of ash known as the Parnell , containing characteristic fossils, and associated with this series of -flows. After a comparatively brief cessation of volcanic activity, ng which forests sprang up and flourished for a time on the land, a series of eruptions began.

The forests were overwhelmed and covered by hundreds of feet of ashes and lavas, first of a semi-basic and then of a trachytic character. During the subsequent time of diminished volcanic activity the embedded trees were in many cases converted into wood-opal by the petrifying action of thermal springs. Great earthquakes were no doubt prevalent in the district, while the cracking of the rocks as they cooled and contracted gave rise to numerous deep-seated parallel fissures running in a general north-and-south direction. Heated vapours, sulphuretted hydrogen, steam and acid gases rose through these channels, and appeared as solfataras and fumaroles, such as are still abundant in the Rotorua and Tarawera districts. These chemical reagents permeated the rock and gradually decomposed it more or less completely, until its original character was quite altered. The metallic constituents and silica were carried in solution along the fissures, and these seem to have acted like voltaic cells in which a strong electro-chemical action was set up. The basic solutions were decomposed and their metallic constituents deposited, the base materials and part of the silver as sulphides, and the gold together with most of the silver as metallic alloy.

Since the last of these eruptions ceased, the greater part of the Hauraki district has remained undisturbed by volcanic action, and the agencies of denudation have during the remainder of the Tertiary epoch been busy wearing down its surface and eroding its stream-channels. The decomposition of the volcanic rocks has made them very soft and friable, so that they offer comparatively little resistance to the action of the rain and running waters. When visiting the Yellowstone National park in America, which in many ways resembles this part of New Zealand, the writer was much struck with this softening action of heated springs and fumaroles on hard volcanic rocks. The magnificent cañon of the Yellowstone river has been eroded out of hard rhyolite or quartz porphyry at a comparatively rapid rate, the rock having become completely rotted away by heated waters and vapours percolating through it from below. Little puffs of steam were visible issuing from cracks in the cañon walls, and the hard rhyolite within their vicinity was so soft that it could at places be crumbled away by the fingers, so that the river had little difficulty in scooping out its channel.

Volcanic activity, although apparently extinct in the Hauraki district proper, was only dormant for a time in the central parts of the island. In newer Pliocene times it burst forth with vast energy, and huge floods of acid lavas were vomited forth over hundreds of square miles of country, while dense clouds of light pumice, ashes, and dust were belched

into the air to fall in thick beds over half the island. Excellent examples of the younger volcanic cones are conspicuous all over the Auckland district, and further south the great volcanoes of Ruapehu, Tongariro, and others are still in a state of modified activity. The solid products of these eruptions reached as far north as Paeroa and Waihi, while the ash-beds are found hundreds of feet thick in the Upper Thames valley and the Upper Waikato. The old valleys were filled up in many cases, a circumstance of importance from a mining point of view, as the outcrops of the reefs were also covered, and a correct knowledge of this fact is essential to successful prospecting wherever the newer rhyolites occur. The well-known Martha Hill at Waihi, through which the celebrated lode of the Waihi Company runs, was surrounded but not quite covered by thick masses of rhyolitic breccias and lavas. The outcrop of the lode outside the company's property cannot therefore be traced on the surface of the ground, and must be sought for by mining operations underneath the latest rhyolitic lavas.

The auriferous reefs are found in bands or belts of propylite or decomposed andesite, separated from each other by hard bands of solid andesite-lava, or indurated tuffs passing into coarse breccias. This propylite is locally known as "sandstone," and is spoken of by the miners as the "kindly rock" of the country, in which reefs may be most confidently expected to occur. The reefs are of the segregated class, having derived their metallic ingredients from the solution of the rock in their immediate vicinity.

Gold is a very widely disseminated metal, and occurs in minute quantities in sea-water as well as in various minerals. In many gold-fields, such as those of Victoria and Western Australia, the best gold reefs are found in a clay-slate country, and this is explained by supposing that the slate was originally a marine deposit which enveloped small quantities of gold at the time of its deposition during the Palæozoic epoch. The action of aqueous solution has subsequently resulted in the leaching out of the gold with other minerals and the redeposition of them along fissures in the rock.

In the case of the Hauraki district, the gold occurs under peculiar conditions and in reefs of Tertiary age, so that here the marine theory is quite inapplicable. The propylites are the gold-bearing rocks, and wherever the reefs pass from this decomposed rock into the fresh rock (or andesite) or into the tuffs and breccias associated with them, they become poor or sterile in character. The inference seems sound that the source of the gold and silver is to be sought in the pyroxenes of the original

andesite, which have elsewhere been found to contain small quantities of the precious metals. It may be mentioned that when visiting the geyser and hot spring district of Rotorua, the writer was told that small quantities of gold were known to occur in the sinter-deposits produced by the geysers, which helps to substantiate Mr. Park's theory that the reefs were originally due to hydrothermal action.

Here, as in other gold-fields, rich shoots of gold are common at the junction of two veins, or where a reef is crossed by a barren cross-vein or "flinty." The theory which has been advanced to explain this, seems satisfactory. On this hypothesis the main lodes were the primary channels or fissures, at one time filled by slowly circulating waters containing gold and silver in solution, while the cross-veins were secondary fissures containing the metallic salts necessary for the electro-chemical deposition of the noble metals.

The gold of the Hauraki district is usually coarse in character, and occurs principally in the form of irregular grains, threads, or scales. Occasionally it is met with in the crystallized form, where it occurs as cubes or octahedrons arranged in short wiry strings. It is alloyed with silver to the extent of 30 to 40 per cent., and thus fetches only from 48s. to 56s. per ounce as a general rule. In the Thames gold-field, the present average fineness is about 680.

The minerals associated with the gold are principally iron pyrites, after which come copper pyrites, zinc-blende, stibnite, and ruby silver, as well as galena, manganese oxides, calcite, pearl-spar, and occasionally metallic arsenic, specimens of the last-named mineral having been found in the Kapanga mine at Coromandel. Before turning from the gold-bearing rocks, it is of importance to note that after much scientific investigation it has been clearly ascertained that the auriferous propylites of the Hauraki district are the same as the volcanic rocks of the famous Comstock lode and Washoe districts of North America, and are also similar to the "country rocks" of the ancient mines of Hungary and Transylvania.

After the district had passed through the changes described, and most of the fissures had become completely mineralized and filled up by quartz-reefs, a new set of geological phenomena arose. The infilling of the fissures was not quite complete, it may be mentioned, as it is common in the mines of the Thames district to find extensive empty cavities, where the fissures are still open and gaping for hundreds of feet at a time perhaps, or again to strike water-channels or acidulated springs following the course of the rents. Most of the reefs, however, were completely

ɜed when the district was again dislocated by earthquake-cracks, ıre still produced during the earth-tremors at other parts of the

large faults were originated in the Thames gold-field, and their ıre very clearly marked by the alteration they have made on the ɔf the country, as well as by their important influence on the ıion of the reefs in that district (Figs. 1, 2, and 3, Plate XVI.). best known of these is the Moanataiari fault which crosses the the reefs at right angles, and runs along the face of the ns from Hape Creek to the shore, a short distance west of ıtown. The effect of this displacement is to produce a great r step on the mountain-slope, as its downthrow side is towards the hades to the south-west at a uniform angle of 45 degs., and it ı calculated that it must have a vertical downthrow of about . The fault forms an abrupt barrier to the mining operations on ırd side, and to regain the truncated reefs on the upthrow side ɜ cross-cutting is necessary. When it was first crossed, it shed so ıter that operations had to be abandoned for a time, and when ɜ north-eastern cross-cut from the 640-feet level of the Big Pump Thames reached its face, a huge mass of soft plastic clay rolled ɜ drift with great velocity, causing the workmen to flee for safety. ral displacement is so great that reefs which have been followed ı seaward side have never as yet been recovered on the footwall or ɨ side. The recent age of the fault is shown by its effect on the of the ground, where its course can be distinctly traced. Where ı one of the mountain-gulleys it has the effect of suddenly con- the glen above and lifting the former bed of the stream up the wider mouth of the part below. A broad part is thus against a narrow portion and a marked and sudden contraction ıpthrow side is clearly visible. Where the fault has been cut in ɜs it has, moreover, been found to contain masses of rotten wood, ts, and decayed vegetable matter in the soft "pug" and clays ıder its hanging wall. These circumstances point to the newer ı, or even later age, of this important displacement.

cond fault of apparently the same age joins the Moanataiari fault ı Collarbone creek. It hades to the south-west at angles of from . to 65 degs., and is locally known as the Collarbone fault, while a ult is supposed to run along the beach at Thames and cut off the the seaward side, but this is not yet satisfactorily proved, as none ɾorkings have crossed into the reefs on its downthrow side.

The geology of the Hauraki district has as yet been only pa investigated, and very little reliance can be placed on the gene geological maps that have been hitherto published. Mr. Park, the director of the Government Mining School at Thames, has r published a good geological map of that locality (Plate XVI.), yet very little encouragement has been given by the New Zealand G ment for geological research in this district, and a systematic geo survey of the whole peninsula is badly wanted.

Mining History.

The discovery of gold in New South Wales in 1851 gave an i to prospecting in other colonies, including New Zealand. In O 1852, Mr. Charles Ring found auriferous quartz and some fine gol the Kapanga stream at Coromandel, a district which afterwards the seat of extensive gold-mining operations. About three th miners were attracted to the field, satisfactory arrangements havin made with the natives for permission to search on their lands discovery of alluvial gold in 1857 at Collingwood, and shortly afte at the Buller river and Tuapeka in the South Island proved, h so attractive that the Coromandel or Hauraki field was for severa practically abandoned. In 1861 a reaction took place, prospecti resumed, and on June 28th, 1862, Coromandel was proclaimed a field by the Government, but the insecurity of the country dur time of hostilities that followed prevented for several years any p in the mining operations.*

Early in 1864, Col. Chesney reported the discovery of alluvial g Te Aroha in the Thames valley, but the disturbed state of the c postponed further developments for a time in that district.

After many negotiations with the natives, which were conclu July 27th, 1867, the Moanataiari and Waiotahi lands, adjoining now the mining town of Grahamstown or Thames, were proclai gold-field. On August 10th, 1867, a very valuable gold-bearing was discovered in the Kuranui stream, and several claims were diately pegged out there and at the mouth of the adjoining Moan creek. This was the beginning of the Thames gold-field, whose quent history has been marked by many splendid discoveries. B August, 1867, and June 30th, 1869, duty was paid at Auckland less than 129,211 ounces of gold, the value of which was pla £264,425; and during the first decade till 1877, this gold-fie

* *Handbook of New Zealand Mines*, *Wellington*, 1887, page 278.

returned bullion to the value £4,110,635 ; but this is exclusive of the gold locally absorbed, the total output having been valued at 4¼ millions sterling.*

The gold in the Hauraki district is more or less patchy, as a rule, and the subsequent annual production of the Thames gold-field has fluctuated considerably. The highest point was reached in 1871, when the value of gold entered for export amounted to £1,188,708. This was due principally to the prodigiously rich shoot discovered in the Golden Crown Company's property, and followed into the Old Caledonian Company's mine, which enabled the latter to pay in dividends £553,440 within twelve months. Over 10 tons of gold are said to have been taken from this mine in as many months. Of late years the production has greatly diminished, and for the year ending March 31st, 1895, only 22,810 ounces were returned from the Thames gold-field—the lowest production since the field was first opened.

Up till 1892, the Thames was the premier gold-field in the Hauraki district, and the mines at Coromandel lagged far behind, as the annexed tables will show. Encouraged by the prosperity at Thames, prospectors gradually extended the range of their operations into the Ohinemuri district to the south, and were successful in discovering valuable reefs in the valleys of the Ohinemuri river and its tributary, the Waitekauri. The principal gold-fields in the Ohinemuri county are those of Waihi, Waitekauri, Komata, Owharoa, and Karangahake. Of the Ohinemuri mines, the Waihi is the most famous, and indeed it has hitherto held the premier position as a gold-producer among all the Hauraki mines, the only other mine at all approaching it in actual output of bullion being the Hauraki mine at Coromandel, which has for some time been happy in the possession of an exceptionally rich little reef. Of late years, mining at Te Aroha has been in a languishing condition, for reasons that will be considered again. Within the last eight or ten years, however, the area of auriferous ground has been found to extend farther south into the Tauranga district on the east coast. Quite recently good reefs have been discovered at Te Puke, about 25 miles from Tauranga, and this district, which has now been proclaimed a gold-field, is being systematically developed.

The most promising, perhaps, of the newer gold-fields of the Hauraki district is that of Kuaotunu, on the promontory north of Mercury Bay on the opposite side of the ridge to Coromandel. Some valuable reefs are being worked and are yielding dividends to the companies that own them.

* *Handbook, loc. cit.*, page 282.

Gold has been found at many other localities, and the accompanying map with the latest information, will give a better idea of the distribution of the mining districts than can be supplied by verbal description. (Plate XV.).

As the country forms a long mountainous ridge, which is only opened up to a very limited extent by roads and bridle-tracks, much of it, of course, is still quite unexplored geologically. The greater part of it is covered by ancient forests and a dense undergrowth of bush and fern, which completely conceals the ground and renders the search for minerals both difficult and tedious.

After wandering in the barren, sandy deserts of Western Australia, where every knoll of rock is visible in its bald nakedness for miles around, rising like a lonely island in the miserable landscape, and every tree and tuft of grass seems to share in the general sadness of that thirsty land, how great a delight to find oneself transported to this charming island! There are no wild animals, snakes, or scorpions in New Zealand, and life here has everything in its favour. The paths to some of the mines visited ran for miles through forest-clad mountains, now winding up a steep ascent, now descending a precipitous slope only to be traversed on horseback or on foot. The horses threaded their way with wonderful dexterity among the spreading roots and hoary stems of ancient trees, shaggy with verdant mosses and festooned with the wonderful rata vine. The path had been cleared by the woodman through a damp and almost impenetrable undergrowth of the graceful tree-ferns, palms, and flowering shrubs that enveloped hill and dale in their bosky mantle. Such is the wealth and luxuriance of the vegetation, that the whole ground, as soon as it is cleared, if left alone for a short time, quickly becomes again overgrown with bush and fern.

To come across mines in such places was somewhat of a surprise, the difficulty of penetrating such a dense undergrowth is considerable, and the obstacles in the way of finding new reefs amidst the damp mould ground are obviously very great. The great kauri pines have during the centuries of their existence on these mountains dropped large quantities of their valuable gum on the ground around them. This has accumulated in lumps resembling amber, and the search for it has for many years been an industry of considerable importance in this part of New Zealand. While prodding the forest glades in search of the valuable gum, quartz reefs have been discovered, and it is an old saying in Scotland that if you show a mine to a miner he will very soon show you a reef to it. Making correct surveys of the claims, again, is a matter of much

labour, but the surveyors are accustomed to deal with these conditions, and the surveys are carried out with great skill and accuracy. The Indian system is adopted, whereby all measurements are made trigonometrically where possible, and the lines through the forest are cleared between the various pegs or observation-stations. All the mines, of course, are not in the heart of the mountains; the great majority are in the slopes round their flanks as yet, but as time goes on there is no doubt that the reefs will prove numerous and rich on the high as well as the lower ground. The surface of the greater part of the Hauraki peninsula has as yet been, comparatively speaking, barely scratched, and there remains a splendid field for the prospector and the enterprising mining engineer to open up. Enough prospecting has been done to show the wide limits between which gold may be expected to occur, and it can be confidently anticipated that before many years are past, with the help of British skill and capital, this will prove one of the most valuable gold-fields in our colonies.

Previous Local Gold-mining.

Although there are, as we have seen, abundance of good reefs in the gold-fields of Thames and Coromandel, mining in these districts was up till 1890 in a more or less languishing condition. Two reasons may be chiefly assigned for this unsatisfactory state of matters. The first of these is financial in character.

The majority of the New Zealand mines were in the hands of local people of little means and small intelligence. As soon as a mine was started on the usual "no liability" system (under which shareholders cannot be sued for calls on shares not fully paid up), it was worked with the old-fashioned plant, common in the locality, and if a good reef were struck all went well for a time: so well that every halfpenny was paid in dividends to the hungry shareholders, and the price of the shares was run up to a high premium. The gold being patchy all over the field, rich shoots cannot be expected to last perpetually, and in such circumstances the folly of disposing of the whole proceeds of an exceptionally rich lead, and leaving nothing over to develop lower levels or poorer parts of the mine, is at once apparent. Not only was this foolish policy prevalent, however; some companies even paid the dividends in advance, hoping to find the gold to meet their expenditure afterwards. When further dead-work became necessary, a call had to be made, and the shares fell quickly in price. In many cases the shareholders either could not or would not pay this, and the companies having no means of enforcing payment under the colonial system of company finance, operations had to be suspended and

the mines closed or sold to the highest bidder at a nominal price. Many of the smaller mines and some of the larger ones in the Thames and Coromandel, as well as in the valuable Reefton gold-fields of New Zealand, have been wrecked on this rock, and have recently come into the market for no other reason. Gold-mining, if properly conducted and financed on sound principles, should be regarded as an industry like farming or ironmaking, where there is always, no doubt, a certain amount of risk, due to non-preventible outside causes, but not much more risk than is inherent in any other legitimate industrial business. Colonials, however, seem to have very hazy ideas of sound financial principles, and, like too many people who are not colonials, they look on mining as a field for pure gambling and speculation, the main idea being to make money quickly by the rise and fall of the shares rather than by the dividends they yield. The gold miners in Victoria have begun to find out their mistake, as they have many most promising mines lying idle which cannot be re-opened for want of capital. When at Ballarat, the writer heard many complaints on this score, to which he replied that if the Victorians persisted in driving out home investors by shady financial transactions they had nobody but themselves to thank for their misfortunes.

The second and, perhaps, more important reason for the recent decline in the Hauraki gold industry has been the inability to treat refractory and low-grade ores by the old-fashioned battery and amalgamation process. Previous to the introduction of the cyanide process, the tailings were generally run off to the nearest creek or emptied into the sea, to the great loss of the proprietors, and it is only within the last five years that this source of loss has begun to be reduced. The average yield of the quartz crushed in the gold-fields of Thames, Coromandel, Aroha, and Ohinemuri since returns were first sent in, was 21 dwt. 9 grs. per ton, the grand total of the quantity crushed up to March 31st, 1895, being 1,045,207 tons for 1,125,514 ounces. Taking these returns as a whole, the average yield is not high, and the price of the bullion being less as a rule than £2 per ounce on account of the large percentage of silver present, it is obvious that unless the percentage of extraction is high and the best system adopted, a mine of average richness can hardly be expected to pay large dividends. This is well exemplified in the Waihi Company's celebrated mine. The Great Martha lode, when under the original Martha Company's treatment for about eight years, only yielded from 4 to 6 dwts., or about 20 per cent. of the bullion per ton, and barely paid its working expenses. When, how-

ever, the mine was taken over and worked with dry crushing and cyanidation by the present Waihi Company, the gold extracted rose to 91 per cent. and the silver to 48 per cent., while great economies were at the same time effected in the working of the plant, the result being that by sheer skill and good management, what had been regarded as an almost useless mine, was turned into one of the best properties in New Zealand. This is what is needed all over the Hauraki district, each reef, of course, requiring its own style of treatment; but whatever system be adopted, it should be the best of its kind, so that there will be no difficulty in making a profit out of every ore that produces over 4 dwts. to the ton.

The Hauraki gold-mining district lies within the four counties of Coromandel, Thames, Ohinemuri, and Tauranga, but the last-mentioned area may be passed over now, as the Te Puke and Te Aroha reefs which it contains are not as yet sufficiently developed for further notice.

Coromandel County.

This is the most northerly of the group, and includes the gold-fields of Coromandel and Kuaotunu located opposite one another on each side of the peninsula.

Kapanga.—The first gold in this part of New Zealand was, as has been already said, discovered in the Kapanga stream, a short distance north of the township of Coromandel in 1852. The Kapanga mine was started in 1862, and was successfully worked for several years, during which large dividends were paid. In 1868, a breakdown took place in a small engine erected at the bottom of the shaft, then 170 feet deep, causing a stoppage in the working of a winze on the leader from which the best gold was being obtained. The Thames gold-field had just then been opened, and the prospects there being so good the Kapanga mine was abandoned and the machinery removed. In 1871, the mine was re-opened and a new shaft was sunk 14 feet by 8 feet in section, which has been working ever since, and has now reached a depth of 800 feet. Two reefs are intersected in the shaft—the Kapanga and Scotty's—at depths of about 500 and 550 feet respectively. These dip or underlie to the south-south-west at an angle of about 30 degs., and as the underlie of Scotty's is less than that of the Kapanga reef above it, it seems very probable that the two will meet when followed down to a lower level. In fact, the impression of the writer when in the workings was that they are really parts of the same reef with a thick horse of mullock between them. They apparently occupy the fissures on each wall of a large fault, the hanging wall of the Kapanga and the footwall of Scotty's being very

clearly defined and marked by slickensides on the face of the country-rock, showing that there has been much sliding along these planes. A diamond bore-hole was recently put down in the bottom of the shaft, the rock passed through was the propylite of the district: this gradually became more decomposed and "kindly" until at a depth of 193 feet a new reef was struck, which may turn out of great value to the company. At the 800 feet level a cross-cut was driven for 700 feet to the west so as to intersect the Kapanga and Scotty's reefs, and in driving this, reefs have been cut which may, on subsequent development, turn out to be the continuation of the expected reefs or the representatives of other leaders passed through in sinking the shaft to the low level. The peculiarity of the mine is the unusually low angle of dip of the fault-fissure in which the reefs occur. Normal faults are not common with a lower hade than 45 degs., and when this angle sinks to 30 degs. the geological inference seems to be that this is either a thrust-plane or reversed fault, such as are common in most mountainous districts, or else that it may have been originally a normal fault whose original inclination has been reduced by a tilting movement during some of the disturbances to which this volcanic region has been much subject. This is a point which cannot be further investigated until a detailed geological survey of the district is carried out.

The development of this mine has not been accomplished without much capital expenditure, and as yet the returns have not been very encouraging. Much gold has been taken out of the upper parts of the Kapanga reef, which is generally small, hard, and highly mineralized. When the writer went through the stopes he was fortunate in seeing some excellent stone detached in which coarse gold was freely visible. Scotty's lode is quite different in character, and the quartz in it is found disseminated among soft puggy material produced by the grinding of the sides during the sliding movement that originated it. Fine gold is obtained from the reef by puddling up this pug and washing it. Although the returns from the mine have hitherto been disappointing, the writer quite agrees with the opinion expressed in the *Mines Report* for 1894 that if the junction of the two lodes can be reached, a highly auriferous block of ground will, in all probability, reward the years of outlay and development during which the shareholders have had to wait.

The present company is, it may be mentioned, the third that has held the ground, and has expended about £70,000 in developing it, in return for which, up to the end of March last, the value of the gold obtained was only £46,600, showing so far a loss of £23,400.

The Kapanga Company, however, had up till recently an adjoining property on the auriferous belt, which was lately sold to the Blagrove Freehold Gold-mining Company, Limited. The operations here are at present confined to sinking, with a view to catching the reefs by cross-cuts. The Blagrove property extends to 130 acres of freehold land, and occupies part of the auriferous belt between the Kapanga and the Hauraki mines.

Scotty's Hauraki, a property adjoining the Kapanga on the north-east, has an area of about 29 acres, and operations are in progress to reach the most valuable part of the Kapanga reef, which runs through the ground, but as yet no quartz is reported to have been crushed by this company.

Tokatea.—This section of the gold-field is situated on the steep spurs f the range, about a mile north of Kapanga, and includes the Tokatea, oyal Oak, Triumph, Harbour View, Bismarck, and other mines, several f which are now in the hands of home capitalists. The original Tokatea ompany started operations in May, 1870, with a capital of £100,000, in),000 shares of £5 each, and up till the end of 1885 had returned over 150,000 in dividends. The mine is worked by a series of levels, the west of which is 3,000 feet in length, and opens up the reef from the utcrop on the top of the main range to a depth of 800 feet. The ines in the Tokatea section, worked partly by wages men and partly by ibutors, yielded for the year ending March 31, 1895, altogether 46½ ns of quartz, which when crushed produced 751 ounces of gold—an crease of 194 ounces over the previous year.

The ordinary method of treatment, by stampers and Berdan pans, is ed here, and as yet nothing has been done to conserve the tailings; hen, however, the new companies start operations with improved stems, there seems every prospect of success in this quarter.

Kauri Block.—This section, situated at the south extremity of the okatea and Kapanga auriferous belt, has lately been the centre of traction in the Coromandel gold-field. It comprises the corner at the harf, on the west side of the Whangarahi stream, about 2 miles outh of Kapanga, and includes the celebrated Hauraki mine, which at the time of the writer's visit was producing over £8,000 worth of gold per month. The lode is about 1 foot in thickness, and runs in a northerly and southerly direction, having an underlie to the eastward of about 60 degrees. There are several other veins running parallel with this lode, all of which contain gold-bearing stone.

The ore is conveyed from the mine through a tunnel about 600 feet long to the battery, which is situated on the seaward slope of the hill near the wharf. The battery consists of 15 heads of stamps with 3 Berdan pans, and when the writer visited it had nothing about it particularly worthy of mention. Gold-reefs running 15 ounces per ton are not common, and can hardly be expected to last beyond a very limited time, but we can only hope that this rich shoot will last long enough to repay to the Kapanga Company, which is an interested party, such a substantial dividend as will compensate to some extent for the want of success in their older mine.

Tiki.—Hitherto the chief gold-producing mines of the Coromandel district have been along the Tokatea-Kapanga-Hauraki belt, which runs from the harbour in a north-north-easterly direction to the crest of the dividing range. There is, however, abundance of evidence of several other rich belts of country running roughly parallel to this within a few miles radius. One of these undoubtedly crosses the ridge and runs into the Tiki ground a short distance north of the Castle Rock. This peak rises grey and bold above the forests like an ancient fortress, and forms a conspicuous landmark some 1,500 feet in height on the crest of the dividing ridge. The strip of ground known as the Tiki property, extending south-westward down the slope from the base of the Castle Rock to the Waiau river, has been found to contain numerous good reefs running in a general north-north-easterly or northerly and southerly direction. Some of these were formerly mined, but for want of working capital and good management they have lately been abandoned, in spite of the excellent prospects they held out. This freehold property, having an area of about 550 acres, is not subject to the mining and labour conditions pertaining to the Crown lands adjoining. It possesses abundance of water-power in the streams that drain the gulleys, and has an excellent battery-site about 1,000 feet below the level of the old workings, to which the ore could be conveyed by gravitation-inclines with great ease. All the Crown lands along the north-western boundary have been lately pegged off, and at the time of the writer's visit to the prospectors of these claims, good gold was showing in some of the reefs. These reefs run directly into the Tiki property, and are traversed at places by cross reefs, which should at their points of intersection give excellent returns.

There is, in addition to the reef gold, every probability of good alluvial gold being obtained near sea-level on the banks of the Waiau and other larger streams fed by the waters in the mountain-gulleys.

Some alluvial work has been done on the lower part of the Tiki property, and among the gold a nugget of 79 ounces was found some years ago.

Kuaotunu.—The Kuaotunu gold-field has as yet been comparatively little prospected, but it is at present yielding satisfactory results to the companies that can treat the ore on a good system. There are several reefs, the best of which—the Try Fluke—runs in a north-north-easterly direction past the eastern side of the Kuaotunu township. The principal mines are the Try Fluke, Red Mercury, Great Mercury, Waitaia, and the Kapai-Vermont. Last year the total amount of quartz crushed and treated in the Kuaotunu field was 8,082 tons, which produced 6,591 ounces, including 2,300 ounces obtained by the cyanide process from 6,518 tons of tailings (from the Try Fluke and Great Mercury mines).

The best reef runs through the property of the Try Fluke and the Kapai-Vermont Companies, and these mines deserve special mention on account of the merits of their system of treatment of the ore, and of the success with which their operations have been attended. The Try Fluke Company has sixteen heads of stamps, three Berdan pans, and a cyanide plant at work. Last year, 6,420 tons of quartz were crushed, and 1,915 ounces were obtained by amalgamation, with 2,084 ounces by cyanidation of the tailings, the value of which was in all £9,330. The cost of increasing plant, mining, treating, office, etc., was £8,409, leaving a profit of £921, which from all accounts is likely to be considerably increased this year.

The Kapai-Vermont Company treat their ore by dry crushing in an Otis mill, and direct cyanidation as at Waihi, and this system appears to be working with most satisfactory results, about 90 per cent. of the assay value of the ore being extracted. Before crushing, the quartz is dried in two kilns 16 feet in diameter at the top and 27 feet deep, each capable of holding from 70 to 80 tons of ore. Like the quartz in the Try Fluke claim, this ore holds the gold in a very finely divided state. The reef has a dip of about 65 degs., and carries gold to a greater or less extent throughout its whole length. During the past year, 588 tons were treated, producing 1,073 ounces of gold, and since then prospects are reported to have greatly improved.

The total production of the Coromandel gold-fields for the year ending March 31st, 1895, was the largest on record, being 22,632 ounces. Of this, however, the Hauraki mine produced for owners and tributors about two-thirds, or 14,961 ounces.

Thames County.

The Thames district adjoins the Coromandel gold-field on the south, and for many years was by far the most important gold-producing part

of the Hauraki peninsula. Up till the end of 1894-5, the gold reported to Government for the previous seventeen years was in all 729,509 ounces, the value of which was about £1,500,000. Adding this to the estimated value given above of the gold produced previous to 1877 (4¼ millions), we may take the total value of the production up to the present time at nearly £6,000,000.

The great majority of the mines are situated within 3 miles of Grahamstown, and the mountains at the back of the town have in the immediate vicinity been well prospected. Mr. Park has recently published an excellent geological map and sections, showing the reefs from which most of the gold has been obtained, a copy of which, to save further explanation, is appended (Figs. 1, 2, and 3, Plate XVI.). The diminishing output of this gold-field is due to the want of capital for deep sinking and developing, as well as for the erection of plant for treatment of the tailings and better extraction of the gold. None of the local batteries in this district are provided with cyanide plant, and there can be no doubt that in the past enormous quantities of gold have been run off with the tailings into the sea. There is in the deeper workings, some of which are carried on at a level of 500 feet below the sea, a considerable influx of water, and this can only be overcome by expensive pumping machinery. The Big Pump shaft is the mainstay of the deeper mines. The shaft was originally sunk by the Imperial Crown Company, whose capital was exhausted before it had prospected the lower levels. It is sunk to a depth of 650 feet below sea-level, and at the mouth is 12 feet by 8 feet in dimension. The pumping engine, erected in 1870, is single-acting, of 250 horse-power, with a 82 inches cylinder and 8 feet stroke, and is capable of raising 84,00 gallons per hour. At 640 feet depth, a level drive runs northwards a southwards from the shaft, and drains the workings of several mines the vicinity. The pump is now the property of the Thames Draina Board, and the funds necessary for its operation are provided by a joi system of contributions from the Thames County Council, Tham borough, and the nine mining companies which benefit by it. T annual cost amounts to about £4,000, nearly half of which is at prese defrayed by the May Queen Company, whose workings necessitate t water being kept down to the 500 feet level.

That there is still abundance of payable ore in the numerous reefs o the Thames district cannot be doubted. It will, however, be necessa y, if the field is to have a prosperous future, to lay out more capit al, and work on a larger and more economical scale than formerly, so as

to obtain good returns from the large masses of low-grade ore that are plentiful in the district. The Moanataiari tunnel, which runs in from the shore for a distance of 3,125 feet under the mountains, might with advantage be extended, so as to enable all the reefs above and around it to be worked cheaply, level free. If this were done, the expense of pumping would be saved to some mines, as there can be no doubt that much valuable ore can be got by this means, without sinking below sea-level.

The Mining School at Grahamstown-on-Thames, of which Mr. Park is the head, is a most useful institution. Practical and theoretical instruction in different branches of surveying and mining is given to students from the whole of the Auckland district. About 35 students were registered last year, and the course of instruction is of great advantage to young men who wish to qualify for mine managers. Those who have gone through the course, and have been diligent students, have generally been successful in getting good situations in this and other colonies, where theoretical, as well as practical, mining knowledge is in much demand. While speaking of the Thames gold-field, mention should be made of Messrs. Price Brothers' foundry and engineering works at Grahamstown. Mining machinery of all sorts, including batteries, pumps, and engines, are made, and all the work turned out is of first-class quality, as can be attested by the managers of the mines in the district. It need scarcely be said that the existence in their midst of such an establishment is of great advantage to the Hauraki gold-fields. The want of such a works in Western Australia, where the nearest machinery works are about 2,000 miles from the gold centres, and it often pays best to bring plant out from home, must, while it exists, be a serious drawback to that colony; and, in comparing the two places, this important advantage for Hauraki, and, indeed, for the whole of the New Zealand gold-fields, must not be overlooked.

Ohinemuri County.

This is at present by far the most important of the Hauraki gold-fields, its production last year being 110,000 ounces—more than twice that of all the others put together. The Ohinemuri mines have this further attraction, from an engineering and scientific point of view, that they exemplify the immense advantage to be derived from the adoption of the most modern system of gold extraction. The difference between profit and loss depends, in many cases, not so much on the mine as on the mining engineer and metallurgist, and the great feature, to the

writer's mind, of this district is the success which has crowned the mines that are conducted on the newest scientific principles. The principal gold-fields in this county are those of Waihi, Waitekauri, and Karangahake, while other mines have to some extent been opened up in the secondary gold-fields of Owharoa, Komata, and Maratoto. This does not, however, include all the auriferous ground, but only a small part of it, as the amount of country explored is comparatively small, and there is every reason to expect that new gold-fields will be opened up in the wide tract of rough forest country, between Waitekauri and the east coast, which, owing to its inaccessible character, has as yet been scarcely penetrated by the white man.

Waihi.—This district differs in topographical characters from the surrounding reefing localities. The reefs occur on rounded knolls or small hills rising from a swampy undulating plain near the head of the Ohinemuri river. The plain is an old broad valley or strath, surrounded by mountains or low ranges of volcanic rock, and the inequalities of its bed have to a greater or less degree been covered up with the deposits of breccia, ash, and rhyolitic rocks ejected, as already mentioned, during the latest series of volcanic eruptions in the Pliocene period.

The chief lode is the Martha, now belonging to the Waihi Company, which runs through the top of the Martha hill and disappears at each end under the rhyolitic lavas of the plain through which the hill forms a protruding knoll. The reef, which is a very large one, was unsuccessfully worked for about eight years before the present company acquired it. When the Waihi Company began operations they obtained at first about 65 per cent. of the gold and 35 per cent. of the silver by dry crushing and pan amalgamation—about thrice as much as was extracted by their predecessors. After subsequent trials of the Cassel process, it was found that the extraction could be brought up to 90 per cent. of the gold and about 50 per cent. of the silver, and since then all the bullion has been obtained by this method. The cyanide plant and battery power has been increased lately, and at the time of the writer's visit the battery consisted of ninety heads of stamps, the cyanidation being carried out in twenty-four vats of 24 feet diameter, with the necessary precipitation boxes, etc.

The tailings which had accumulated before the introduction of the new process were sold for £5,000 to the Cassel Company, who began their recovery operations in February, 1894, and have since treated about 20,000 tons, from which they have obtained bullion to the value of £25,000. The appended diagrams (Figs. 4, 5, and 6, Plate XVII

the general arrangement of the plant used by the Cassel Company
Waihi. The success of this company led to the adoption of the
de process by the Waihi Company.

fter a series of careful experiments in wet and dry crushing the
i Company found that the best results were obtainable by crushing
re dry with stampers and treating it directly by the Cassel process,
ut amalgamation. The method of treatment found to be so suc-
ıl is as follows :—

'he ore in which the gold occurs in a very finely divided state is
d into circular kilns 20 feet in diameter at the mouth and 37 feet
excavated in the soft rhyolitic rock of the rising ground behind the
ry. It is mixed with fire-wood and dried by burning, and every
day is drawn off below, half a charge or about 50 tons at a time, so
ıt to allow the kilns to cool down. The dry ore is then run into the
ry-house, crushed by rock-breakers and dropped into challenge ore-
ırs which work automatically and obviate much manual labour. The
ps have a weight of 900 pounds and crush 1½ tons in twenty-four
s, the average number of drops per minute being about ninety-two.
mortar-box, which is deep and has a large discharge, is fitted with
forty-mesh screens, through which the dust is splashed like the pulp
ı ordinary wet battery. It falls into a long narrow trough running
g the whole length of each line of mortar-boxes, and is drawn to one
by means of an Archimedean screw and discharged into a bin. From
the pulverized ore is lifted by a bucket belt-elevator and passed
ugh a separator, which returns the coarser portion to the stamps
further pulverizing, the fine dust being conveyed to a long hopper
ıing the entire length of the cyanide-house. The hopper, which is
feet long, has twenty doors for discharging the sand into trucks.
se are run over any part of the twenty-four cyanide vats by travelling
, which can be moved laterally by hand-gearing. The sand is tipped
small shower into each vat, so as to fill it up uniformly without pack-
that is, without allowing the finer dust to accumulate in layers, which
ıt interfere with the adequate circulation of the solvent through it.
vats are circular, 22½ to 24 feet in diameter and 4 feet in depth, of
h 5 inches is occupied by the filter-bottom, a wooden grating covered
strong hessian cloth which acts as a filter. Each vat holds about
ons of ore, and four days are occupied in filling, treating, and sluic-
ıt out. When the vats are filled to a depth of 2 feet, a solution of
ide of 0·4 per cent. is introduced under the filter-cloth and forced
hrough the sand till it covers it to a depth of 2 inches. The solution

remaining under the filter-cloth is then drawn off and filtration begins, the 2 inches on the surface taking about twenty-four hours to percolate through. After the whole of the strong solution has been drawn off, a weak stock solution is run on to the top of the ore to a depth of 6½ inches. The cock connecting with the vacuum-cylinder is then opened, and in about thirty hours the second solution has passed through. Finally, about 10 inches of water is run on to the top, and after this has been drawn through, the operation is completed, the sludge-door is opened, and the sand sluiced out by two 2 inches hose-pipes under a head of 50 feet of water. The precipitation-boxes are 16 feet long, 2 feet deep, and 17 inches wide, and are divided into twelve compartments, of which the first and last are sand-filters to clean the solution going in and to prevent any gold slimes being washed out. In dry crushing, such as this, there is a good deal of dust produced, but by having dust-chambers and keeping the battery-boxes and conveyors well covered in, this inconvenience has been minimized. The presence of so much light, dry dust in the air is no doubt a good deal prejudicial to the health of the men exposed to it, and the men who wheel the ore from the bin to the vats must work with a cloth over their noses when opening the doors and filling the trucks. By the use of automatic Archimedean conveyors, elevators, and other labour-saving appliances, however, very few operatives are required. When sixty heads of stamps were working, the whole labour required in the battery and cyanide-house was only that of two men and a boy per shift.

As the company possesses valuable water-rights, steam-power is not required for the greater part of the year. The power is supplied by six 6 feet Pelton wheels, which are ample for the present requirements, but spare steam-power is provided in case of a diminution of the water-supply in dry weather. The company are, however, contemplating the addition to their plant of a new battery of 100 heads. This it is proposing to erect at a lower level on the Ohinemuri river, the ore being brought down from the mine by a tramway. The immense body of ore in the Martha lode gives promise of a great future for this company. The main shaft was down to a depth of 239 feet at the date of last report, and the stopes were 20 to 30 feet wide and 700 feet in length, while large quantities of quartz were still being obtained from the great opencast on the top of the hill. A view of Martha hill is shown in Plate XIV.

Last year's work at Waihi resulted in the crushing of 24,210 tons of quartz, which produced 61,132 ounces of bullion, valued at £84,925 6s. 11d. Since then the production has continued to increase steadily,

e month ending September 21st, 1895, 3,000 tons had been oducing bullion to the value of £10,733. As this is a typical ıay be of further interest to give the details of the cost of l treating the ore, as supplied in the *Mines Report* for 1894-5, ı most of the present figures are derived.

	Costs. Total. £	s.	d.		Per Ton. £	s.	d.
... ...	12,915	3	9	...	0	10	4·66
! ore to kilns	346	8	1	...	0	0	3·34
es	3,924	12	9	...	0	3	1·46
rough rock-breakers	786	15	0	...	0	0	7·59
... ...	2,664	2	4	...	0	2	1·71
›f bullion: cyanide and zinc ...	4,651	6	0	...	0	4	6·36
... ...	3,547	19	1	...	0	3	5·48
r and wages, etc.	2,130	18	0	...	0	1	8·56
d melting	524	16	2	...	0	0	5·06
plant, etc....	1,295	5	9	...	0	1	0·50
aperintendent and officers, rents,							
;y, freight on bullion, etc. ...	5,811	1	0	...	0	4	3·18
ses, London	2,266	10	8	...	0	1	9·88
... ...	111	19	9	...		—	
	40,976	18	4		1	13	9·78

ight of quartz crushed and value of bullion won by the pany during the last five years is as follows :—

	Quartz Crushed. Tons.		Value of Bullion. £.
... ...	—	...	20,930
... .	—	...	23,934
... ...	18,236	...	44,883
... ...	19,805	...	61,895
... ...	24,864	...	82,820
November 16	29,830	...	102,589
Total			337,051

ne success of this company was assured, numerous others alongside of it, but as yet none of them have been successful the Martha reef. There are, however, other reefs at Waihi, h it may be mentioned was originally worked without much this company before the Martha was acquired. Another is eing mined by the Waihi Silverton Company, but as yet no e been reported, and all the works are of a preliminary nature. Grand Junction Company are searching for the Martha lode overing of rhyolite and ash already mentioned at the eastern Martha hill, and if the reef be found to continue in that direc-

tion, as may be reasonably expected, the company have good prosp of ultimate success. Many other claims trading on the name of Wa but having really no geological right to do so, have been pegged of the vicinity within the last few months.

Waitekauri.—This gold-field has long been known as a good ree district, but up to this year it has received but little attention fi outside. The township is situated in the steep glen of the Waitek stream, and all the surrounding country is mountainous, and thi covered with bush and valuable kauri forests. The only mines consequence are the Golden Cross and the Komata, situated in the b about 4 miles north-west of the township. Both these mines are now property of the Waitekauri Company. The ore is treated as at Wa but in addition to this, the excellent system has been adopted of pas the tailings from the cyanide-vats over amalgamated plates, so a catch any particles of coarse gold too large to be dissolved by cyanide. The reefs are thick and of good quality, although very but at the time of the writer's visit to part of the property the p pects were excellent.

The property of the Komata Reefs Company, situated in the imm ate vicinity of the Waitekauri Company's ground, contains several l and good reefs which, at the time of the writer's visit, were being e getically opened out by Capt. W. H. Argall (the manager).

Karanjahake.—The mines in this section are situated on the sid the steep gorge of the Waitawheta river, at its junction with the Ol muri. The district is now being developed by home capitalists, and three principal mines belonging to the Crown, Woodstock, and Talis Companies, respectively, are giving very satisfactory returns. Last the total amount of quartz crushed was 5,113 tons, and from this 15, ounces of gold was obtained, chiefly by cyanidation, a result wh must be very pleasing to the shareholders. Of these mines, the Cr has the largest property, and was the means of first introducing cyanide process to the district. Dry crushing with stamps and cyan tion are used, as at Waihi, and the steepness of the ground and abund of water provide ample power and good sites for batteries.

Production of the Hauraki Gold-field.

The following table gives the production of the Hauraki mines the figures were first supplied to the Government :—*

* *New Zealand, Reports relating to Minerals and Mining*, 1895.

District.	Year Ending March 31.	Quartz and Mullock Crushed or Sold. Tons.	Yield of Gold. Oz.	Average Yield of Gold per Ton. Oz. dwt. gr.
Coromandel	1881	720	4,960	6 18 0
"	1882	3,358	7,352	2 4 0
"	1883	2,907	7,577	2 12 0
"	1884	1,043	4,018	3 17 0
"	1885	456	3,201	7 0 0
"	1886	550	3,382	6 3 0
"	1887	305	4,170	13 13 0
"	1888	1,923	6,774	3 10 5
"	1889	2,149	8,090	3 15 7
"	1890	1,690	6,708	3 19 9
"	1891	5,650	9,838	1 14 19
"	1892	13,029	12,191	0 18 17
"	1893	15,163	12,954	0 17 2
"	1894	12,629	9,969	0 15 18
"	1895	15,451	22,632	1 9 18
	Totals	77,023	123,816	1 12 4
Ames	1879	41,917	57,207	1 7 7
"	1880	33,017	59,576	1 16 2
"	1881	32,405	53,154	1 12 19
"	1882	30,698	45,803	1 9 20
"	1883	25,867	43,311	1 13 12
"	1884	34,228	54,878	1 12 2
"	1885	31,496	37,705	1 4 4
"	1886	35,998	61,540	1 14 4
"	1887	34,827	38,142	1 1 22
"	1888	32,819	35,949	1 1 11
"	1889	47,363	35,796	0 15 3
"	1890	60,753	33,817	0 11 14
"	1891	61,756	38,113	0 12 8
"	1892	86,110	45,735	0 10 15
"	1893	78,547	31,336	0 7 23
"	1894	62,444	34,637	0 11 2
"	1895	48,464	22,810	0 9 10
	Totals	778,739	729,509	0 18 18
Ohinemuri	1888	2,388	3,406	1 8 13
"	1889	3,795	3,679	0 19 9
"	1890	4,773	8,564	1 15 21
"	1891	9,902	12,914	1 6 2
"	1892	13,865	23,659	1 14 2
"	1893	22,771	43,405	1 18 3
"	1894	31,281	35,666	1 2 18
"	1895	51,058	110,628	2 3 8
	Totals	139,833	241,921	1 14 14

District.	Year Ending March 31.	Quartz and Mullock Crushed or Sold. Tons.	Yield of Gold. Oz.
Te Aroha ...	1884 ...	4,262 ...	4,629 ...
„ ...	1885 ...	11,042 ...	9,506 ...
„ ...	1886 ...	6,552 ...	4,489 ...
„ ...	1887 ...	4,743 ...	3,658 ...
„ ...	1888 ...	7,166 ...	2,918 ...
„ ...	1889 ...	1,381 ...	1,113 ...
„ ...	1890 ...	4,894 ...	20,416 ...
„ ...	1891 ...	280 ...	557 ...
„ ...	1892 ...	2,722 ...	979 ...
„ ...	1893 ...	3,169 ...	1,178 ...
„ ...	1894 ...	2,270 ...	833 ...
„ ...	1895 ...	1,121 ...	628 ...
	Totals ...	49,602	50,904
Grand totals from North Island..		1,045,207	1,125,514

It is instructive to note from these statistics that the Ohine trict now returns not only the greatest quantity of gold, but also tl average extraction of gold per ton of ore. This is due to the in all the leading mines, of the best scientific system of treati when such processes are employed in the other gold-fields ther doubt, be a marked improvement in their returns also.

For the year ending March 31st, 1895, the mines in the district produced altogether 116,094 tons of ore, from which ounces of bullion were obtained—97,471 ounces by the cyanid and the rest by amalgamation. The value of the bullion was ₤ and the increased production this year will greatly swell the : the next report.

The whole quantity of ore crushed in New Zealand during was 171,433 tons for 181,442 ounces, worth about £358,250. produced in the five districts of Hauraki, Marlborough, Nel Coast, and Otago, and it is thus clear that the first of these ₤ now produces twice as much as all the others put together.

In addition to the gold from reefing-districts, a large qu produced from the alluvial-fields in the Middle Island. Last total quantity entered for exportation was valued at £889,545, that as yet more than half of the New Zealand gold is deri alluvial workings.

The chief mines in the Middle Island are in the mountainou of Reefton, on the West Coast, near Greymouth. This gold-f pares favourably with the Hauraki district in some respects, and

a passing notice here. The Reefton mines are in a slate country, and the gold, which is very pure, is worth on the average about £4 1s. 6d. per ounce. It is a remarkable circumstance that, although some of these mines have been sunk to depths of over 1,000 feet, or 200 feet below sea-level, so little water has been met with as to render the use of pumping machinery unnecessary. Another advantage enjoyed at Reefton is an abundant and cheap coal supply from neighbouring collieries, while the mountains are covered with timber, and water-power from the heights is easily available. Hitherto the Reefton district has been practically unknown in Great Britain, and the various mines have been worked with local capital in the old-fashioned wasteful style, to which reference has already been made. Assays have proved that fully half of the gold has been lost in the tailings during the fourteen years the mines have been in operation. Notwithstanding this waste, however, the Reefton mines have produced altogether, from 653,000 tons of quartz, about 467,000 ounces of gold, valued at £1,824,000, from which dividends to the amount of £574,000 have been declared by the different companies.

In conclusion, the contents of the preceding pages may be summarized, in a few lines, by remarking that :—

1.—The Hauraki district, from its geological formation, which is similar to that of some other rich mining regions, promises, if properly developed, to yield for many years a steady output of gold, and become a source of great profit to capital and labour alike.

2.—This district possesses exceptional advantages in having water-power, and high ground for many of the mines, so that they can be cheaply worked level free by adits. Timber is also abundant, good machinery obtainable in the vicinity, coal comparatively cheap, and for the mines near the coast the means of transit are excellent.

3.—As a rule, the ore is low grade and more or less patchy, and the value of the bullion is not very high, but the reefs are numerous and sometimes of great size.

4.—In these circumstances the mines cannot, on the whole, be profitably worked, except by companies with large properties, ample capital for developments, extensive plant for the effective working and treatment of large quantities of ore, and capable management in both the financial and practical departments.

5.—Hitherto the small companies, without adequate working capital, have proved quite incapable of carrying out these conditions, and the future welfare of this and other gold-fields in New Zealand depends, to a great extent, on the influx of outside capital.

6.—Such being the case, it is clearly wise on the part of the Government to continue their present policy and carry out the valuable suggestions of Mr. H. A. Gordon, the inspecting engineer of mines.

7.—Large mining areas, and the securest form of tenure, should be granted to those who provide the means of developing them, while labour conditions should be made as light as possible, and, in short, no opportunity should be neglected of fostering private enterprise in gold production, as it is clearly impracticable for any government to undertake the risk of carrying on such a large industry as gold-mining, with any probability of direct advantage to the public exchequer.

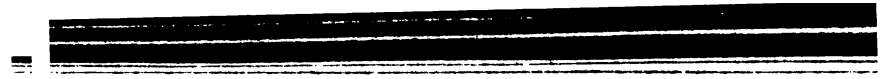
Happily, the present government seems fully alive to the best interests of the colony in this direction, and if its policy is steadily adhered to the benefit will very soon become apparent. The old system has been tried and found wanting. The dawn of a brighter day is appearing, and it is hoped that the future will fulfil the promises that are now so clearly held forth.

The discussion of the paper was adjourned.

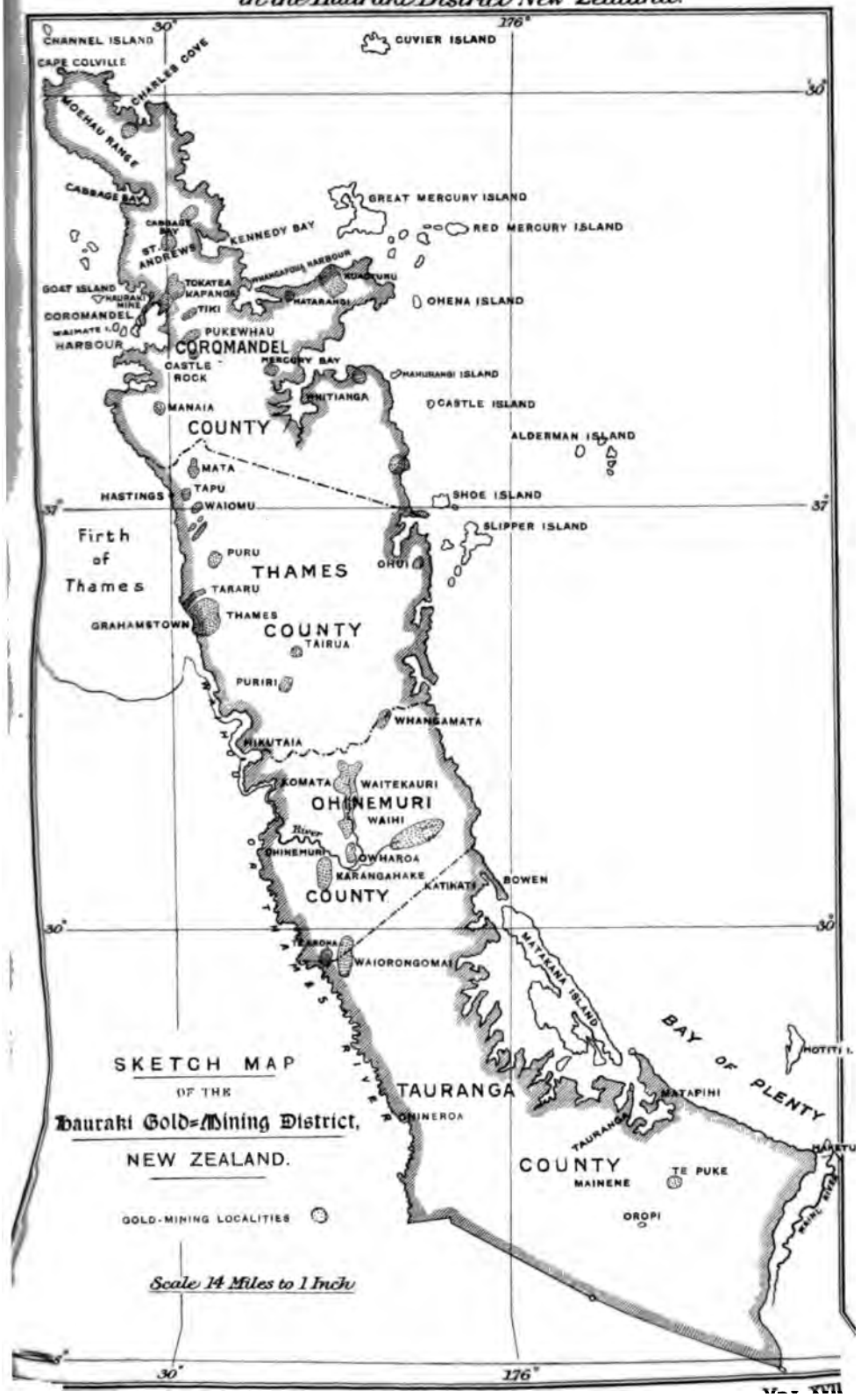
The meeting was then closed.

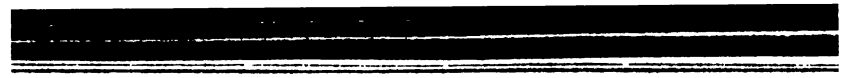
...ining Institute of Scotland.
Transactions, 1895-96.

THE MARTHA HILL, AT WAIHI.



To illustrate M.r H.M. Cadell's Paper on "Gold-mining in the Hauraki District New Zealand."





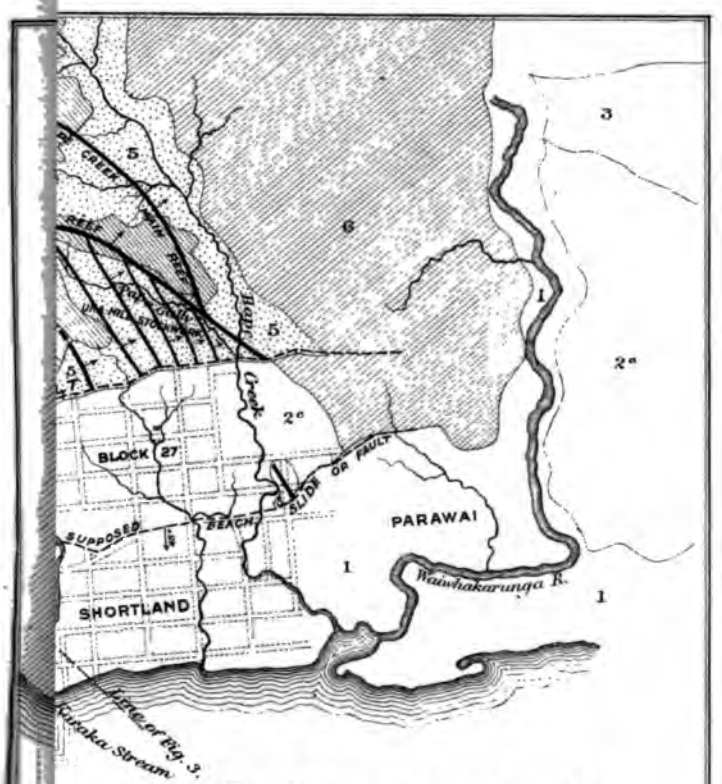
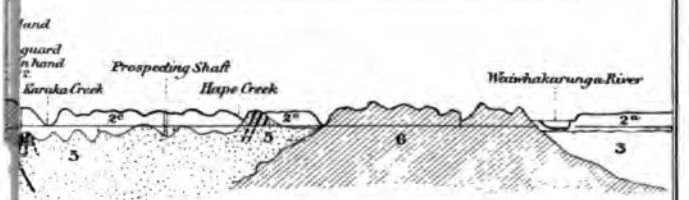


FIG. 1.—GEOLOGICAL MAP
OF THE
THAMES GOLD-FIELD,
NEW ZEALAND.

HORIZONTAL AND VERTICAL SCALE FOR PLAN AND SECTIONS.
2,600 FEET TO 1 INCH.



REFERENCE.

L FLATS AND SWAMPS, BEACH , &C.

NE—
YEL GRAVEL TERRACES.

ON OF BOULDERS, SAND, MUD, ELOW SEA LEVEL.

YEL TERRACES OF BOULDERS, LS, SANDS, &c.

D ANDESITE AGGLOMERATES

4 HORNBLENDE-ANDESITES & TUFFS, FORMING THE "HARD-COUNTRY" OF THE MINERS.

5 DECOMPOSED ANDESITES & TUFFS, FORMING THE "SOFT" OR "KINDLY COUNTRY" OF THE MINERS.

6 ANDESITE BRECCIAS, AGGLOMERATES, AND TUFFS. SELDOM CONTAIN GOLD-BEARING REEFS.

7 PALÆOZOIC—
BLUE SLATY SHALES.

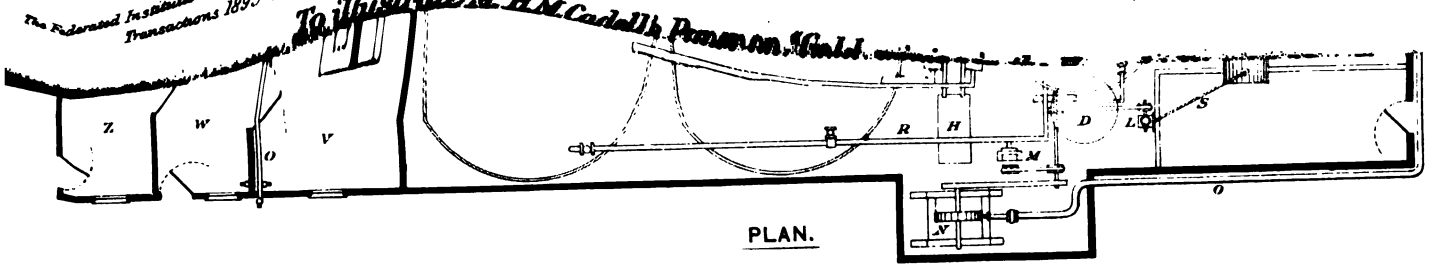
8 YELLOWISH-COLOURED MUDSTONES.

GOLD-BEARING FORMATION.

REEFS.

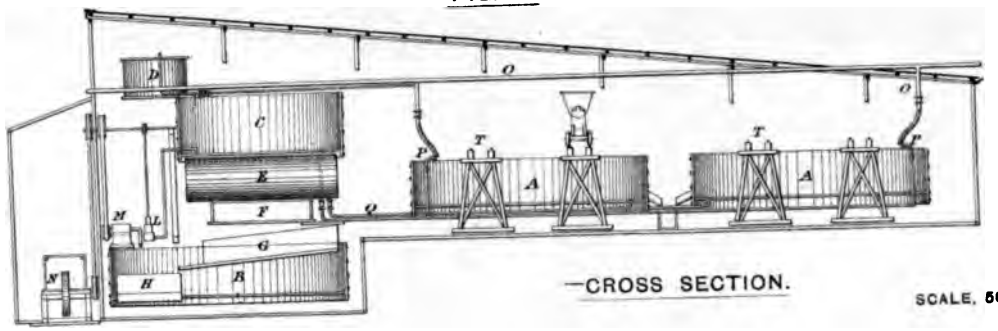
The Federated Institution of Mining Engineers
Transactions 1895-6.

To illustrate Mr H.M. Cadell's Paper on Gold.



PLAN.

FIG. 6.



—CROSS SECTION.

SCALE, 50 FEET TO 3 INCHES.

Mining Institute of Scotland
Transactions 1895-6

And.w Reid & Comp.y L.td Newcastle on Tyne

CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

SPECIAL GENERAL MEETING,

HELD IN THE STEPHENSON MEMORIAL HALL, CHESTERFIELD, OCTOBER 12TH, 1895.

MR. EMERSON BAINBRIDGE, PRESIDENT, IN THE CHAIR.

The SECRETARY announced the election of the following gentlemen:—

MEMBER—

Mr. CHARLES EVERSON, Surveyor, Sheepbridge Works, Chesterfield.

STUDENTS—

Mr. BEAUMONT HENRY CHECKLAND, Blackwell Collieries, Alfreton.

Mr. HENRY EUSTACE MITTON, Blackwell Collieries, Alfreton.

STEPHENSON MEMORIAL HALL.

The PRESIDENT remarked that the next business was to consider the agreement referred to in the following paragraph of the agenda paper:—

"Stephenson Memorial Hall.—The terms of an agreement proposed to be entered into between the Town Council of Chesterfield and this Institution will be communicated and explained to the meeting, with a view to the execution of the agreement being authorized. It is for this purpose that the meeting is made special."

The SECRETARY read the proposed agreement.

The PRESIDENT said that the members who were familiar with the manner in which this building was erected many years ago by the public spirit and enterprise of those interested in engineering, finding something like £10,000, it could not be very palatable to feel that by this agreement the Institution had changed its position with regard to the building, but it would not serve any good purpose to go over ground already discussed. The Council advised and recommended that this agreement be executed and passed by the meeting, and whilst inviting remarks from any member, he begged to move that the deed be executed.

The resolution was carried *nem. con.*

DISCUSSION UPON MR. H. R. HEWITT'S PAPER ON "AN UNDERGROUND ENDLESS-ROPE AT THE MOSTON COLLIERY, MANCHESTER."*

Mr. W. SPENCER (Leicester) remarked that Mr. Hewitt stated the working cost of the new system to be one-quarter of that of the old.† It seemed to him that there must be some mistake, and he would like to have further particulars. He had always considered, and he thought the opinion was very generally held, that they could not have anything simpler and more effective than the old method, *i.e.*, the rope being taken out by the empty tubs, but here they had a very heavy gradient, and the rope gripped by a clip which was liable sometimes to damage the rope, and yet they were told that the cost was only one-fourth of that of the old system. Perhaps the explanation might be that the old system was worked by compressed air and the new system by steam-power. That would account for a considerable difference. The saving, he thought, must be due to something else than the difference in the system of haulage.

The PRESIDENT suggested that the original cost must have been much in excess of the usual amount.

The PRESIDENT then delivered the following address:—

* *Trans. Fed. Inst.*, vol. viii., page 377, and vol. ix., page 178.
† *Ibid.*, vol. viii., page 381.

PRESIDENTIAL ADDRESS.

By EMERSON BAINBRIDGE.

In accepting the honour which you have conferred upon me in electing me as President of this Institution, I am aware that it is usual for an address to be delivered from the presidential chair, and the importance of such an address is greatly increased by the fact that through the existence of the Federation of the various mining institutions of the kingdom, the words that may fall from the President of one of the affiliated Institutions may meet the eye of the whole of the federated members. I should like to add one more word of congratulation on the advantages of this Federation—not only in bringing mining engineers more often together in friendly and mutually useful intercourse, but in giving much greater weight to that body in the engineering world, and in disseminating, by means of the excellent papers read, the experience and knowledge of a few to the advantage of all.

It has perhaps not been the lot of any of your former Presidents to have to address the Institution at a time of such severe "storm and stress" as we are now experiencing, when to a great extent the problems and difficulties of engineering are overshadowed by the anxieties and perplexities of the economic situation. Although, therefore, there are many tempting subjects in the field of engineering which I might have chosen to speak upon, I propose to ask you to consider with me the commercial aspect of the coal industry, the conditions which are militating against its prosperity, and the possible remedies which may be available to restore it to a more healthy and prosperous state.

The members of this Institution are concerned with the coal trade, and whilst as engineers our duty is to study the best modes of overcoming the difficulties of mine engineering, it is our aim as colliery managers to produce coal at the lowest possible figure and in the best possible condition. The finding of a market for the produce of a mine falls naturally more within the province of a colliery manager than of a mining engineer; but in times like the present it is questionable whether the commercial question has not become as important a feature in colliery management as the engineering.

Coal is undoubtedly the primary factor in the commercial greatness of this country. It is to its coal that the present position of Britain in the markets of the world is mainly due, and without the continued production of cheap coal, that position cannot possibly be maintained. Thirty years

ago, Britain was in a preferential position as regards coal which she does not occupy to-day. Her coal was of excellent quality and easily accessible, and it was produced close to the sea-shore. Hence it was more easily worked and brought to market than the coal of other countries in Europe, which for the most part exists at great depth and inclined at steep angles, or is found in somewhat remote places.

During the period referred to, the better organization of labour has increased its value as part of the cost of producing coal. On the other hand, whilst railway rates in Europe and America have undergone radical changes in favour of the coal producer and consumer, in Great Britain they are practically the same as they were thirty years ago.

The importance of these two points will be understood when it is remembered that out of the total cost of a ton of coal, the wages cost may be said to average 65 per cent.; and of the total pit price that a consumer pays for coal in the inland trade, the cost of railway rates will, on the average, amount to not less than 35 per cent. of the total delivered price paid; the cost of railway freight in the Midlands, where prices are as low as they have been during the past year or two, amounting very often to more than the value at the pit of the coal itself.

Many years ago, the general trade of the Continent of Europe was greatly hindered in its progress by the exhaustion caused by great wars, by antiquated political conditions, and fiscal restrictions, and by want of commercial experience. The railway, the telegraph, and the steamship have helped to alter all this; they have practically annihilated distance, and they have brought into closer conjunction all the markets of the world. Merchants now no longer merely buy and sell in the markets of their own country; the produce of the whole world is open to them, and almost every country, however remote, is enabled to offer its productions in competition with those of every other on the face of the globe.

But whilst the commercial position has developed in this remarkable manner, the conditions which determine the cost of production vary in different countries almost as much as ever they did; and while the market price of a commodity tends to become equalized with every development of the means of transport, the cost of production remains to a very considerable extent unchanged. The price of Russian or Indian wheat is determined by the quality of the sample as compared with home-grown wheat, but the payment of the Russian peasant or the Indian labourer has scarcely altered. The corn-grower in those countries, however, is constantly able to introduce improved machinery, which enables him to produce still more cheaply, and every year new railways give him better facilities for placing his article on the world's market.

And as with corn so with coal. The last twenty years has witnessed a number of developments of deep coal-fields in Germany, which could not have been worked but for the scientific contrivances which have been devised to overcome great natural difficulties, and in overcoming these difficulties our German *confrères* have obtained in certain directions a high position of efficiency in mining appliances.

The Germans have taken from this country a large slice of the Baltic trade, and we may not yet have seen the full extent of this displacement. But it is not only in Europe that English coal is being driven out by foreign competition. In the Far East, in countries hitherto uncivilized and unexplored, new coal-fields of great richness have been discovered, and these when developed (as they will be) not only by European enterprise but by the industry and shrewdness of such races as the Japanese, cannot fail to have a permanent effect in limiting the export of coal from this country. In every country, except Amercia, the labour-cost in the production of coal is very much lower than in England, partly on account of the lower rates of wages paid for a given production of mineral, and partly on account of the longer hours worked by the colliers. In Oriental countries, where the cost of living is very small, the remuneration of labour is of course a mere trifle as compared with that of European countries, but even in comparing these latter with each other we find remarkable contrasts in the amounts which are paid to the miner for the production of coal.

The following table, which appeared in an article written in the *Contemporary Review*, is prepared from figures brought by the miners' leaders from the Congress held two years ago, and shows that the wages of colliers in England are 6s. per day, as compared with 3s. to 3s. 6d. in Germany and in France, and 2s. 6d. to 2s. 8d. in Belgium and Austria, and these lower wages are paid for considerably longer hours than the English colliers work :—

	Average Wages Paid Per Day.		Remarks made by the Delegates at the Conference.
	Colliers.	Fillers.	
England	6s. to 6s. 4d.	4s. 9d. to 5s.	Leaves no room for reduction.
Austria ...	2s. 8d.	2s. 8d.	Out of which they pay 20s. per month for house rent.
France ...	3s. 6d.	2s. 7d.	Work 10 to 11 hours per day.
Belgium	2s. 6d. to 2s. 8d.	—	
Germany	3s. to 3s. 6d.	—	Workmen are not looked upon or treated like human beings, and work 12 hours a day.

It is obvious that a system under which the workmen of one country receive a greatly higher rate of pay and shorter hours than is paid in other countries, thus enhancing the cost of production, must place that country at a great disadvantage so long as the conditions of labour in other countries remain unaltered, and it is a remarkable testimony to the energy and skill of the mining engineers of England that they have been able hitherto to compete successfully with foreign countries, notwithstanding the disadvantages against which they have had to contend. It is clear, however, that the success of this struggle is no longer assured.

The general position of the coal trade of this country may be briefly summarized as follows:—1st. There are in Great Britain about 4,000 coal-pits, and over the last six months it may be safely asserted that one-half of these have been losing money, and the other half have, on the average, yielded but a bare rate of interest on the capital invested. 2nd. Throughout the kingdom about forty new collieries are being sunk or opened out, and as a rule, the promoters of these undertakings are arranging plant to yield large outputs with the conviction that in the competition which is taking place, and which will continue, it is only possible to hold one's own by keeping down the cost of production by means of a large output. 3rd. The special engineering economies which have been applied to mining in recent years are the development of coal-cutting by machinery driven by electricity and compressed air, a depth of 4 feet 6 inches under the face having been reached by the wheel-cutter; great advantage has been gained also by the application underground of steel girders as props and bars, but the high first cost, both as regards coal-cutting and girders, has, in the existing state of the coal trade, placed a serious obstacle in the way of the application and development of these economies; another important economy has arisen in the development of improved systems of sorting, picking, and washing coal, and in this respect we are getting gradually more on a level with the French and German colliery-owners, who long ago recognized the great importance of dealing with these questions; important strides have also been made in reducing the cost of the coal consumed at collieries, and by means of firing with forced draught and mechanical stoking, coal practically unsaleable has been utilized. A further important economy is now in vogue in which the waste heat in boiler firing is used to heat the feed water in a much simpler way than the ordinary tube economizers.

The fact that some of the chief advances in mining engineering, which promote economical working can be referred to in so few words, emphasizes the importance of looking for a remedy for the present state of the coal trade in some other direction.

In the past it has generally been accepted as a fundamental axiom that the rate of wages to be paid in any industry must depend upon the amount obtainable for the commodity produced; but of late years a new doctrine has been promulgated, suggesting that instead of prices fixing wages, wages must first be fixed and must determine prices. This was the question on which the coal strike of 1893 turned. An organization of labour in the mining industry had been created by a body of able labour leaders, and they accomplished what must ever be regarded as a most notable achievement, the concentration of the efforts of a large community in one combined effort to maintain wages. At that time, those whose capital was at stake in the coal trade were not able to combine their forces so completely as their workmen, although, *prima facie*, it would have appeared the more possible combination of the two; but, with the differences of financial position, of the conditions of different mines, personal jealousies, and varying markets, it is probable that nothing short of absolute disaster can weld the colliery-owners of Britain into a solid body, capable of dealing with industrial questions. The great battle of 1893 was fought with disastrous results. It was a struggle fought, on the one hand, with the clear conviction that economic law was inexorable, and would, in the end, bring about its invariable result.

The coal-owners knew perfectly well that an artificial rate of wages could never permanently promote abnormally high prices, and, on the other hand, the workmen fought for their position (untenable though it was) with a determination which eventually ended in their gaining their point for the time being.

The coal trade of this country received such a blow as it will probably never entirely recover from, and we are at this moment experiencing the effect of an attempt to fly in the face of an elementary principle.

At the present moment it is interesting to endeavour to realize what the experience of two years teaches us.

The present position of the mining labour question throughout the country is briefly as follows:—

In Northumberland wages now stand at 7½ per cent. higher than in 1871, in Durham they stand at 15 per cent. higher, in South Wales at 12½ per cent., and in Scotland they stand on the average at about 15 per cent. higher.

Throughout the rest of England, that is the district covered by the Miners' Federation, and comprising North Wales, Lancashire, Yorkshire, Derbyshire, Notts, Leicester, Warwick, Somerset, and Cumberland, the

wages paid, with a few exceptions, are 30 per cent. over the standard price, and will remain so until August 1st, 1896. In the districts other than the Federation districts, the wages are regulated to a great extent by the state of trade, and the state of trade from time to time is accurately ascertained from the accounts showing the selling prices of the coal and coke sold.

It is possible that the miners in Wales and in the North may, when noticing that they are again in each district called upon to agree to a further reduction of 2½ per cent., look somewhat anxiously upon the Midlands, and think that the 30 per cent. paid here is something to envy. It is scarcely less likely that the miners of the Midlands will be feeling some exultation in considering their relative positions. As one interested in both districts, I submit that for many months past the respective position of the two districts may be indicated by the following figures:— Midlands, 3½ days worked per week at 6s. per day, 21s.; add 30 per cent., 6s. 4d.; weekly wage, 27s. 4d. North of England and Wales, 5 days worked per week at 6s. per day, 30s.; add 15 per cent., 4s. 6d.; weekly wage, 34s. 6d.

These figures are submitted with the knowledge that for the past six months many collieries in Derbyshire have not averaged more than two days' work per week. If these figures were only approximately correct, they indicate that as regards the miners themselves, the solution of the labour difficulties of 1893 was unwise and against the best interests of the men, and it is a question whether the miner in the Midland counties has ever been in so bad a position as he has been during the past six months.

In seeking for some mode of promoting the coal trade of England in future, without damaging the general trade of the country, the following leading principles must be borne in mind:—1st. That if by any means the cost of coal in this country is raised higher than the cost in competing countries the general trade of this country will suffer. 2nd. That if the cost of the coal be brought down, even temporarily, to a low figure, it is likely to stimulate industries in which the cost of fuel is an important factor.

There is little doubt that the improvement in trade of which there are now some signs, is partly due to the low prices at which coal has been sold, owing to the special competition brought about by over production, and thus the financial straits of the colliery-owners and the low weekly wage of the workmen have been (in this respect) to the advantage of the general consumer.

In aiming at any scheme for the maintenance of better trade, the following principles may be laid down :—

1.—That as the miner in selling his labour disposes of all he has in the world, he should receive sufficient wage to support himself and family.

2.—That he has a right to some voice in fixing the price (if some feasible way can be devised for taking counsel with him) at which the coal he produces is disposed of.

3.—When the falling off in the demand for coal so far reduces its selling price as to leave the capitalist little or no interest upon his capital (compelling him in many cases to seek relief from the royalty-owner) the miner should accept a bare living wage.

4.—With improved selling prices, the collier should participate in the extra price realized.

To many, these points may appear as truisms, but in seeking for a *modus vivendi*, as applied to the coal trade, it is well to have them clearly laid down and understood.

The legislation of the past does not appear to encourage the hope that much can be expected in this direction, and before discussing certain remedies, which may be practical or otherwise, it may be well to consider, judging from the past, what assistance the coal trade is likely to receive in this direction.

The happiness of the people of this country must depend to a large extent upon the ability of those who live by manual labour to rely upon a regular means of subsistence, and this can only be secured by the maintenance of commercial prosperity : and yet, in the past, it is a question whether one-tenth of the time of the Houses of Parliament has been taken up with commercial questions.

Some Acts have been passed, and some committees appointed, but it is doubtful whether they have been of the least use to the trade of the country, except as a means of ventilating the subject.

A few years ago, a committee on the depression in trade sat for a great length of time, and took voluminous evidence, but no advantage appears to have arisen from this.

Then as regards mining specially, a commission sat with regard to royalties, which had the effect of forming the lessors of mines into an association for giving evidence on their own behalf, and no benefit to the coal industry is likely to ensue from the work of this commission.

Referring, however, to a much more important measure, the complaint of freighters some years ago brought forward the Railway Rates and Charges Bill, and after an immense amount of money had been spent by the freighters on the one hand and by the combined railway companies on the other, there is practically very little gain—up to the present—to the coal and other heavy trades, from this act.

Recognizing the great loss entailed on the country by strikes, endeavours were made by the last House of Commons to pass a bill to promote arbitration in labour disputes, and although probably no bill is so much needed, it was, through pressure of much less important matters, not put forward.

Some of the possible remedies for preventing such a condition of the coal trade as has been in existence for the past year or two, and which is present to the mind of every colliery-owner in this country, in looking forward to the future, may now be referred to:—

1.—*The Prevention of Strikes.*—The more one contemplates the object and effect of a strike, the more one comes to the conclusion that those—to whichever side they may belong—who are responsible for its occurrence on a large scale, are almost criminally blameable.

In an article written on the coal strike of 1893, the writer estimated the aggregate cost of that important stoppage at thirty-three millions, and no doubt other strikes have been proportionately costly.

Such occurrences have one great result in the way in which they stimulate foreign competition, and it is well known that the boot strike of last year has given quite a new impetus to the importation of American boots to this country.

If both sides only realize the importance of the matter, they will do their best to assist the present Government to promote such an Arbitration Bill as will tend to prevent trade being damaged by the occurrence of great strikes.

France and Germany spend huge revenues yearly in keeping ready for a struggle, and capital and labour in the coal industry, on a smaller scale, occupy very much the same position. I look forward to a time when the only outlay in this direction will be that necessary to pay the officials on both sides for carrying out a scheme of settling all labour disputes by arbitration. This would not put an end to miners' unions, but, by making the expense of maintaining such unions less than one-tenth of what it now is, would increase their numerical strength and importance.

2.—*Underselling due to Competition.*—There is no problem so difficult to solve as that of endeavouring to discover some means of preventing

a large number of producers of the same article from so pushing that article on the market that they obtain for it less than the buyer can fairly afford to give, and, during the past four years, in which prices have gradually been getting lower, many schemes have been discussed with a view of preventing what is generally referred to as "reckless competition."

In dealing with this question, there are two classes of consumers to be considered—those who, like householders, do not find 6d. or 1s. in the price of coal an important consideration, and consumers on a larger scale, like gas companies, who can generally afford to pay more than the low price which is offered to them as the result of the feverish competition of colliery-owners.

On the other hand, there are consumers who, like the iron producer, must buy at the lowest possible price when the iron trade is in its present condition, and this also applies to the export trade, where Britain enters into competition with foreign countries.

It therefore appears that if an endeavour be made to effect a combination to maintain prices, a different mode of treatment will be required for different customers.

It has always been the desire of every body of men possessing what they believe to be a monopoly to extract from that monopoly the greatest amount of advantage to themselves. Monopolies of various kinds were secured by the favour of kings and sovereigns in the Middle Ages, but they invariably failed, because either the monopoly was deprived of all practical value, or the public necessities broke through the artificial restrictions. Many years ago, when the coal trade of the North of England was the most important in the country, an attempt was made to regulate the selling price, and, in order to make this as high as possible, to limit the output. It was an utter failure, and in the end brought many collieries to ruin. Such a scheme is now impossible in this country when confined to any particular district, but it has been proposed that a restrictive organization on a sufficiently comprehensive basis might be of great advantage both to capital and labour in the coal trade. There is at the present moment an example of such a combination in Germany, which hitherto has been attended with successful results. Practically, the whole of the collieries in the coal-field of Westphalia and Rhenish Prussia, numbering about 180, are combined in a gigantic syndicate, to which they have surrendered entirely the sale of their coal and coke, no colliery being permitted to deal with any of its own produce without the consent of

the managing body of the syndicate. Competition is therefore entirely eliminated, and the production can be regulated in accordance with the demand. The collieries which can be most economically worked can be continued, and those which are less favourably situated can be stopped, while the owners of these last are compensated out of the common fund. Having the entire command of the home market, the syndicate is enabled to sell in competition with foreign countries, and hence with many advantages as regards wages, royalties, and other burdens, they are practically enabled to give a bonus on the coal against which the English collieries have to compete. This arrangement has evidently been satisfactory to the members in the past, as it has recently been extended for a term of years. Permanent success will depend on whether the trade of the consumer who buys the coal and coke suffers through that price being higher than it would be when open competition exists.

The late Sir George Elliot propounded a scheme for combining the greater part of the collieries of this country in such a way as to remove to a considerable extent the difficulties of competition, and secure the most economical methods of working, while making some provision for the participation of labour in the profits of trade. Although this scheme had many excellent features, its magnitude was such that there was little hope of bringing it into workable shape. There is, nevertheless, a great likelihood that if a number of competing collieries formed themselves into one company in any particular coal-field, they would be much more likely to work with advantage; whilst concentrating and economizing the cost of administration, they would constitute a stronger body in arranging labour and royalty questions, and such an amalgamation would do much to reduce the evil consequences of competition in selling.

It is questionable, however, whether any combination which endeavours to unduly raise the price of a commodity so universally needed as coal can ever be maintained without prejudice to the general welfare of the country. It is not in coal only that our country is experiencing the severity of foreign competition. Almost all our staple industries are hard pressed, and the iron trade in particular has the greatest difficulty in maintaining its position. If the price of fuel is to be artificially maintained to any serious extent, it is clear that the iron trade must languish and be gradually driven out of the field by the competition of those countries which can obtain their fuel on easier terms; and when it is considered how large a proportion of our manufactures are for export, the gravity of the question becomes still more apparent.

It is, above all, imperative that we should realize our position as producers compared with other parts of the world, and I cannot emphasize this point better than by repeating the remark made at the last meeting of the Iron and Steel Institute by a great American ironmaker in reference to a well-known North of England colliery-owner. The American said: "I have been trying to understand how my friend can get such a good price as 10s. per ton for his coke in Durham, and I have been trying to make him grasp the fact that I can produce my coke in America at 3s. per ton!" The startling character of these figures indicates that the industrial question cannot be considered without a full recognition of the fact that some newer countries are better placed than we are as regards economical production.

3.—*Reduction of Output.*—Some of the labour leaders suggest as a remedy for the present state of things the limitation of the production of coal. They say: "Reduce working hours. Limit the number of working days, and we shall then get for the hours and days we work the same amount of money as we shall do if we allow unrestricted competition to increase the supply beyond the point which is required by the demands of trade."

They do not realize the fact that it is impossible thus to regulate the production of coal throughout the markets of the world, and that every ton by which the British output is reduced correspondingly increases the output of some foreign country; that the price at which the world's markets will be supplied will not be materially affected whether the English production is slightly greater or less, and that, therefore, the sole effect of reducing the output would be to diminish the aggregate wage-fund which the British miner receives.

4.—*Co-operation.*—The true principle which may, perhaps, some day be evolved out of disaster and misfortune is the principle of co-operation. Co-operation which will yield to capital a reasonable return commensurate with the risks and uncertainties of mining, and to the workmen as large a proportion of the product of his industry as the condition of trade will afford. The arrangement by which wages vary with prices on a sliding scale is a rough and ready way of arriving at such a result, and obviates many of the practical difficulties which would be inseparable from the working of collieries as co-operative societies. Unfortunately the idea of a sliding scale is opposed by some of the labour leaders, who appear to think either that the coal-owner does not care sufficiently to develop his business to the fullest possible extent, or they distrust the means available for accurately ascertaining the results of trading, or they hold to the idea of endeavouring to make prices depend on wages.

In conclusion, I may briefly summarize the various measures which appear to be available for the improvement and maintenance of the coal industry of the country :—

1.—The adoption of such a system of arbitration as will make it compulsory for both sides to submit a statement of their case to a satisfactory tribunal, so that the position of matters may be considered by such tribunal, and be understood by the public before any important strike is resorted to.

2.—The recognition by all the parties interested in the production of coal that, with the shrinkage of demand in the general trade of the world, a temporary reduction of prices must necessarily take place, following the same law as the increase in price which is due to and which will follow an active demand; and the adoption by all parties of the principle that the country which most promptly adjusts its conditions of production to the demand will be most likely, in the long run, to maintain the largest quantity of trade.

3.—In the interests of both colliery-owner and miner, a conference on the question of the best mode of preventing the throwing down of selling values by useless competition appears to be very desirable, and the experiences which the Westphalian coal-field has gained over the past eighteen months cannot fail to be of advantage in considering this aspect of the question.

Finally, I feel sure I am expressing the general feeling of the colliery-owners of this country when I say that they are, as a body, wishful to carry out any arrangements which will enable the workmen to participate in the results of any improvement in trade which may take place from time to time; and, on the other hand, if the miners recognize the fairness of the principle that workmen should share with the owners the occasional burden of depressed times, there will be a better chance in the future than there has been in the past of maintaining the prosperity of the coal trade, and to this end the colliery-proprietors and mining engineers of the country, aided by such institutions as this, will not fail to take advantage of every scientific appliance that will promote economical production.

Mr. A. H. Stokes (Derby) proposed a vote of thanks to the Presi[illegible] for his address. Mr. Bainbridge had chosen for his subject the econom[illegible] relations of employer and employed, with suggestions for future guida[illegible] There was, however, a commercial aspect not mentioned in the addres[illegible]

ı to the royalty owner and the great amount of money that was
· the interest upon accumulated funds in the hands of colliery

. JOHN JACKSON (Clay Cross), in seconding the vote, said he hoped
ıe President's address would be carefully studied by all concerned.
l listened to it with much interest, and he could not help feeling that
lennium had not yet arrived, and that they were still very far from
ıg the system so ably illustrated to them, and which would, if
l, be to the mutual benefit of employers and employed. It would
be more satisfactory to have uniform conditions of trade, than a
ıation of the erratic changes that had prevailed since the great
e in 1893, and he felt sure that the figures mentioned by Mr.
idge, with regard to the wages earned in the North of England
South Wales, where with lower wages the men were earning more
should be taken to heart.

: PRESIDENT, in expressing his thanks for the vote, stated that it
h some personal self-sacrifice that he had chosen the subject for his
. It would have been more congenial to him to have referred to
ıeral question of the progress of mining engineering, but he
; it would be of greater service if he brought forward a subject
at the present time, was uppermost in the minds of most colliery
rs. It was, perhaps, too much to expect at present that the
ion made could be carried out, but he thought that consideration
ı sides of the various points raised might be of some service.
:gard to the remarks made by Mr. Stokes about mining royalties,
ere, it was true, large accumulations of royalties and rents prepaid
iery proprietors to lessors, but they had to ask themselves the
ı: Who is responsible for these engagements? Speaking as a
-owner, he took the responsibility for any mistakes that he had
ı this respect. A man had to choose for himself, and if he made a
gain and paid £20,000 more than he ought to have done, he had
nself to blame. It was often a matter of competition between rival
ers or lessees. This question was well considered by the Royalty
ssion, and after they had taken many folios of evidence, they
ılly came to the conclusion to leave things as they were. He
hanked the members for the kind way in which they had listened
ddress.

fixed below the cage. It was not only advantageous in saving the shock at the bottom of the shaft, but it also reduced the very unpleasant noise and saved the cage from much wear-and-tear. If the cage rested on a spring, the shock was not only reduced, but the spring helped to raise the cage in the first moment of winding.

DISCUSSION UPON MR. L. W. DE GRAVE'S PAPER ON "CONTINUOUS-CURRENT DYNAMOS AND MOTORS."*

Mr. A. H. STOKES said that he would like to sound a note of warning as to a fault often committed, and to suggest two remedies. He frequently found that in putting down electric plant the engineer under-estimated the maximum horse-power which the motor might be called upon to bring into active operation. Motors and dynamos were put down too small for the work which they had to do, and when failure took place the engineer blamed electricity. Now, in all cases where electricity was used, it was a mistake not to provide an excess of power. Another suggestion was that the wires should be sufficiently large to convey, not only the current for ordinary work, but an enlarged current should it be required at some future time. Probably Mr. de Grave would give the percentage, but he should say there ought always to be at command 50 per cent. more power than was required for regular work.

Mr. CHARLES MARKHAM (Broad Oaks ironworks, Chesterfield,) endorsed Mr. Stokes' statement. He used electric power extensively, and had five motors running at his works. When a motor was bought, it was marked so many volts and ampères. If they attempted to get more volts out of it, difficulties immediately ensued. Electric motors must not be overpowered. If a motor was bought to exert 10 horse-power, that was "electrical horse-power"—not ordinary horse-power as understood by mechanical engineers—and if it was tried to get 11 horse-power out of it, the risk of failure was incurred. It was thus imperative, as Mr. Stokes said, that the motor must be large enough for all the work that it might be called upon to do. Another place where motors generally went wrong was in starting, unless they had good resistance-switches, and motors running free. Motors that had to be continually stopped and started did not seem to answer. Mr. Webb, of Crewe, tried a number of electric cranes, but the constant stopping and starting of the

* *Trans. Fed. Inst.*, vol. ix., page 195.

dynamos did not answer, and he had to adopt a continuous-running dynamo and belts, so as to avoid reversing the machines. The voltage ordinarily employed was 100; 60 would be considered rather old-fashioned. For pit work they could generally employ pressures of 400, 600, and even 1,000 volts. But it was a great question, in his opinion, whether this high voltage was not extremely dangerous, in view of the liability to a breakage in the cables or their too close proximity, which might cause a short circuit and sparking. He would like to hear the whole subject discussed, because he was not satisfied as to what was the proper system to adopt in electric haulage—whether to have the multiple-phase system or the continuous current.

Mr. C. J. OLIVER (Chesterfield) asked whether motors could be worked at a slower speed—say, one-half the normal speed—without serious loss of efficiency?

Mr. J. A. LONGDEN (Stanton-by-Dale, Nottingham) said that the conditions under which electricity was used in a colliery were widely different from those that applied at Mr. Markham's works. Mr. Markham possessed various machines driven by motors: these required a constant load, and there would be consequently tolerably uniform running. There was a great disadvantage at collieries in starting with the full load on, and all the *vis inertiæ* to be overcome besides; but the motors would give out 50 per cent. above their maximum safe-working power for a short time without any harm, and that enabled them to start easily with a dead load. At the same time, he entirely endorsed Mr. Stokes' remarks with regard to having ample power, and he was of opinion that the success at Pleasley—and he thought it could be considered a success, as they had run four years with hardly any stop of consequence—was largely due to that fact. They had 100 electrical horse-power constantly in use for hauling underground. The point he wished particularly to emphasize was that, if they had a sufficient reserve, electricity was an extremely convenient power for use down a pit.

Mr. L. W. DE GRAVE (Derby) in reply said—Mr. Stokes suggested that inequalities in the metal were the cause of the burning away of the commutator-bars. In the early days of electric machinery, when commutator-sections were cast, this was not unfrequently the cause, but, nowadays, when the sections were almost universally made of rolled copper, there was not much likelihood of this being the cause, although it was possible for the quality to vary even in the same bar. It was now over five years since he had come across a fault due to bad metal in

machines of good make. Mr. Stokes also referred to the danger of sparking both from motors and cables used in a fiery atmosphere. For motors, the only practical safeguard was the Davis and Stokes safety-commutator to which Mr. Deacon had referred, and which he had so fully described before this Institution,* that it was unnecessary to do more than mention it. There were several so-called safety-cables, but none of them in his (Mr. de Grave's) opinion could equal the ordinary concentric cable with the inner conductor of copper highly insulated with vulcanized indiarubber, and the outer conductor of galvanized iron or steel wire, bare or simply braided over; the advantage being that the iron or steel wire was sufficient to withstand the ordinary rough usage of pit-work, and in the event of a heavy fall of roof or being run over by a tram, etc., the two conductors would be forced into electrical contact, thus forming a short circuit, which would burn the fuse either in the engine-house or at the pit-bottom. With regard to alternating-current motors Mr. Stokes was under a slight misapprehension; alternating-current motors built on the polyphase system were both self-exciting and self-starting. It was possible, however, that Mr. Stokes was thinking of the small continuous-current dynamos used for exciting the field-magnets of the generators.

The Sayers commutator-coil was a special arrangement of wire on the armature, intended to eliminate the necessity of altering the lead of the brushes as the load varied, but it did not prevent sparking from anything but this cause. With regard to the relation between field-magnet design and sparking, a weak magnetic field would cause sparking which could only be cured by strengthening the magnetic field.

In reply to Mr. Stokes' question as to the percentage of margin which should be allowed in cables; for ordinary lighting work, this should be anything from 25 to 100 per cent. depending upon the probability of more or larger lamps being required. For power-transmission, the cable has to be calculated for each case, the size of cable for a certain duty depending on the relation between interest on capital outlay and power lost in the cable. This was a point to be decided by the engineer or whoever was responsible for the results, and he should be told exactly what work the motor had to perform, and if further power was likely to be required in the near future. It was bad commercial policy to spend a large sum of money on a cable for an extra capacity which might not be required for years.

* *Trans. Fed. Inst.*, vol. iii., page 191.

With regard to the loading of motors, Mr. Markham stated that a 10 horse-power motor gave trouble if called upon to produce 11 horse-power. All he (Mr. de Grave) could say was that it did not say much for the motor if it caused trouble, because its horse-power of 10 was exceeded by one. He had run 15 horse-power motors up to 25 horse-power for short periods of three to four hours without any ill effects, but, of course, it was not a thing that he cared to do regularly. Referring to Mr. Markham's other remark as to the maximum voltage which should be taken underground, he (Mr. de Grave) stated in his paper that he considered 500 volts quite sufficient, and in the majority of cases such a voltage did not make the cable too large. Sparking between cables was impossible unless electrical connexion was first made between them. There were such things as automatic magnetic cut-outs, where the man starting the motor could place his finger on the cut-out and hold it in until the current was down to its normal; then if anything went wrong afterwards the circuit would be automatically broken.*

There was a great loss of efficiency in running a motor at a less speed than it was designed for, and it was far better to alter the mechanical gearing. The multiphase system had no advantages over the continuous-current system for the transmission of power over comparatively short distances, say 4 or 5 miles.

THE REV. J. M. MELLO.

The PRESIDENT said that before they passed on to any other business, he wished, on behalf of the Institution, to acknowledge the gratuitous and very kind services rendered by the Rev. J. M. Mello in connexion with the Museum, and he thought that they should ask the Secretary to place on the minutes a resolution recording the obligation which the Institution felt, and to send a copy of the resolution to Mr. Mello.

This was unanimously agreed to.

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* Mr. de Grave drew a distinction between a cut-out, which was a mechanical contrivance (worked electrically) for breaking the circuit and a fuse which melted and performed the same operation, the former only requiring to be lifted up by the finger to reform the circuit, the latter requiring a new wire and the use of a screw-driver.

DISCUSSION UPON MR. A. H. STOKES' PAPER ON "PHOTOMETRIC VALUE OF, AND NOTES UPON, VARIOUS ILLUMINANTS USED IN MINES."*

Mr. A. S. Douglas (Hucknall Torkard) remarked that some years ago he introduced an illuminant into the collieries with which he was connected, and he believed he recognized that illuminant as one experimented upon by Mr. Stokes. He had from time to time experimented, with the result that he had substituted a mineral oil for the mixture of colza oil and petroleum which had previously been used. The results fully justified the change; and he suggested that the experiments fully endorsed his view, and showed the superiority of the mineral oil used alone over the mixture.

On testing the sample of colzaïne, the mineral oil used at the Hucknall collieries, he (Mr. Douglas) obtained better results by 0·20 than those of Mr. Stokes in his first series of experiments.† This may be accounted for by the fact that the form of the safety-lamp had been somewhat altered, so as to afford a little more air-space, and to ensure more perfect combustion. The Marsaut lamp now used had slotted holes formed in the horizontal top ring. Formerly small round holes were bored, but they soon became clogged up. The mixture of oils, having a composition nearest to that recommended by the Royal Commision, viz.:—"Two-thirds Lille colza and one-third royal daylight petroleum," did not appear to come out well, being only seventh on the list out of twenty-three samples tested. It should be noted that the mineral oils tested by Mr. Stokes gave better results on the average by 0·12 candle-power than the mixtures of vegetable and mineral oils.

With an uncovered colzaïne flame, he (Mr. Douglas) found that the intensity of light of a standard candle was in no case reached, the nearest only giving 0·94. Mr. Stokes found that the difference between one of the colzaïne oils burning in a Marsaut lamp fitted with two and a single gauze was (experiments Nos. 16 and 28) 0·55 candle-power; he (Mr. Douglas) had not found it to exceed 0·29 candle-power. If, however, the oil he had used was similar to that experimented with by Mr. Stokes in Nos. 15 and 27 experiments, the result, viz., 0·27 candle-power, almost coincided with his own. It was evident that there was a

* *Trans. Fed. Inst.*, vol. x., page 135. † *Ibid.*, page 141.

very considerable difference in the two qualities of colzaïne used by Mr. Stokes, one apparently being much more suitable for burning in Marsaut safety-lamps with a single gauze (experiments Nos. 16 and 28). The mixture of "two-thirds Lille colza and one-third royal daylight petroleum" is only tenth on the list of fourteen tests (Table II.) *

There did not appear to be much difference (only 0·04 candle-power) in the intensity of light between mineral oil and the mixture of vegetable and mineral oil. It might have been anticipated that this difference would have been considerably higher, as being free burning oils the single gauze would have been more favourable to the mineral oil than to the mixture of vegetable and mineral oil. As a matter of fact the reverse was the case.

	Double Gauze.		Single Gauze.		Difference.
Average candle-power of mineral oil	0·45	...	0·91	...	0·46
Average candle-power of the mixture of vegetable and mineral oil ...	0·33	..	0·87	...	0·54

On comparing experiments Nos. 80 and 81 (Table V.)† with Nos. 16 and 28, there appeared to be a difference of 0·22, which it is assumed was due to the use of the white enamelled reflector. Experiments Nos. 82 and 83 show a difference of 0·26 candle-power, which bear this out. In the case of the mixture of vegetable and mineral oils, there is a large discrepancy between the results given in Table V. and those in Tables I. and II., amounting to 0·46 candle-power. This is too large an amount to be credited to the reflector, and would appear to point to some error in Mr. Stokes' observations. He (Mr. Douglas) had made several tests to determine the value of a reflector; the results, however, obtained by Mr. Stokes' are more than double those which he had obtained (0·26 and 0·10 candle-power respectively).

As far as colzaïne is concerned, he (Mr. Douglas) agreed with Mr. Stokes' time-test results given in Table X.‡ He found that 15½ hours were required to burn 2 fluid ounces, as against 15 hours 35 minutes shown by Mr. Stokes. The large difference in the rates of burning between the two classes of colzaïne tested by Mr. Stokes, together with the difference in the lighting-power, indicate clearly the variations and inequalities of this type of oil.

The mixture of two-thirds Lille colza and one-third of royal daylight petroleum was twelfth on the list (Table X.) out of sixteen oils

* *Trans. Fed. Inst*, vol. x., page 142. † *Ibid.*, page 146.

‡ *Ibid.*, page 149.

tested. The weight of fluid burnt per hour, contrary to his (Mr. Douglas') expectations, favoured the use of mineral oils; the average of the tests being: mineral oil, 15 hours 17 minutes, as against oil mixtures, 13 hours 54 minutes, corresponding to a difference of 5 grains burnt per hour in favour of mineral oil.

Table X. would be more interesting and valuable if average photometric readings had been taken throughout the tests, as they would probably have been found to largely favour the use of mineral oils.

Table XI.,* containing a comparison of the rate of burning of oils, intensities of light and costs, showed that colzaïne burnt in a lamp with a single gauze was a very economical oil, and yielded good light, being in this respect similar to colzaline, and that even in the case of the double-gauze lamp it gave a better result than mixtures of vegetable and mineral oils.

It appeared clear from Mr. Stokes' experiments that the mixture of oils recommended by the Royal Commissioners of 1886 is much inferior in illuminating power to most of the mineral oils tested; that the double gauze, while largely decreasing the illuminating power of all oils, affected more particularly vegetable oils and mixtures of oils.

It would have been interesting if Mr. Stokes had given the flashing-point of the various oils used in his experiments, as it might form an important factor in determining the value of any particular oil. He (Mr. Douglas) believed, however, that the oil known as "brilliant colzaïne," and which is one among those tested by Mr. Stokes, had a sufficiently high flashing-point (264 degs. Fahr.) to preclude any suspicion of danger in its storage or use. It appeared to be one of the best illuminants tested, lamps burning it were easy to light, the wick required practically no snuffing, it was one of the cheapest of oils experimented upon, and its lasting power was great. The price, though not of the greatest importance, deserved, in these times at least, some consideration at the hands of colliery managers. Being satisfied that a particular oil was safe and cheap, the only question that could arise was its illuminating power. Mr. Stokes' tests spoke for themselves, and would, he (Mr Douglas) thought, commend colzaïne and similar classes of illuminating oils to the more general notice of the members.

In safety-lamps burning mineral oils, the best results are obtained by using fine wicks, which should only just show above the top of the burner; and when so set the light will burn without perceptible dim- inu-

* *Trans. Fed. Inst.*, vol. x., page 150.

tion of intensity for four hours without attention. The objection raised by users when a mineral oil is substituted for a vegetable oil, or a mixture of oils, often arises from ignorance on this point. They raise the wick to the same height in both cases, resulting (in the case of the mineral oil) in the top of the lamp-gauze becoming quickly covered with soot and the light consequently greatly diminished.

With the oil used at the Hucknall collieries, a workman has seldom to employ his pricker more than once a day for snuffing his lamp, its use being almost entirely confined to raising or lowering the wick.

The photometric results given by the Commissioners on Accidents in Mines show that the oils tested were—seal, rape, best colza, mixtures of colza and petroleum, and colzaline spirit, the light in the case of seal oil burnt in a Marsaut lamp with two gauzes being as high as 0·72 candle-power, and in a Marsaut with three gauzes 0·54 candle-power. These results seem very high, and similar results do not appear to have been reached by Mr. Stokes in his experiments. A Mueseler lamp burning colzaline only gave 0·40 candle-power. The highest illuminating-power of any of the oils tested was possessed by seal oil, burning in the Fumat lamp (with two gauzes) No. 1, and showing 0·79 candle-power.

The extra gauze in the Marsaut lamp no doubt materially increases its safety, but this addition largely decreases the illuminating-power of all the oils tested, more especially is that the case with mixtures of vegetable and mineral oils.

Colzaïne, and oils of the same type, being free-burning, a slightly larger air-space than is found in some of the safety-lamps in use is an advantage: it conduces to more perfect combustion, and he (Mr. Douglas) had found in several cases that in adopting these oils some slight alteration was necessary to such lamps in order to obtain good results.

It should be borne in mind that in actual use in mines safety-lamps are often exposed to strong currents of air, which in some cases considerably affect the purity of the flame and increase the production of smoke.

A good test to ascertain the capabilities of an oil and its non-smoking qualities is to subject it to the swinging test, viz., to suspend a lamp with string from a certain height, say, 6 to 10 feet, and set it in swinging motion, to-and-fro. This will cause a sudden rush of air alternately on each side of the lamp, and will be valuable in ascertaining the free-burning properties of the oil and its tendency or not to produce smoke.

There is no doubt a distinct advantage in the use of reflectors, both for concentrating the light and shielding the workman's eyes from the glare of the oil-flame, the only point in dispute being its exact value. As, however, enamelled reflector-glasses can be had at a very slightly increased cost, they appear well worth adopting.

The meeting was then closed.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE INSTITUTE ROOM, BARNSLEY, DECEMBER 14TH, 1895.

MR. JOHN NEVIN, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. JOHN WM. CRAVEN, Mechanical Engineer, Westgate Common Foundry, Wakefield.

Mr. HERBERT HINCHLIFFE, Assistant Manager, Bullhouse Colliery, Penistone, Sheffield.

Mr. WM. SUTTON, Colliery Manager, New Hemsworth Colliery, Wakefield.

Mr. BATEMAN WANLESS, Mechanical Engineer, Garforth, Leeds.

STUDENT—

Mr. HARRY RHODES, Mining Student, Rotherham Main Colliery, Rotherham.

Mr. H. ST. JOHN DURNFORD read the following "Notes on the Sinking of the No. 1 Pit at the Ackton Hall Colliery":—

NOTES ON THE SINKING OF THE No. 1 PIT AT THE ACKTON HALL COLLIERY, WITH SPECIAL REFERENCE TO THE THINNING OUT OF THE SILKSTONE AND BEESTON COAL-SEAMS.

By H. ST. JOHN DURNFORD.

The sinking of the No. 1 Pit at the Ackton Hall colliery was commenced on October 17th, 1892. It might be as well to state that the colliery is situated between Wakefield and Pontefract, on the Lancashire and Yorkshire Railway, and in close proximity to the Featherstone station, about 200 feet to the north of the railway. The nearest colliery at present working is the Featherstone Main, about ½ mile further north, the shaft is sunk to the Haigh Moor coal-seam, and both that and the Stanley Main coal-seam are worked (Fig. 1).

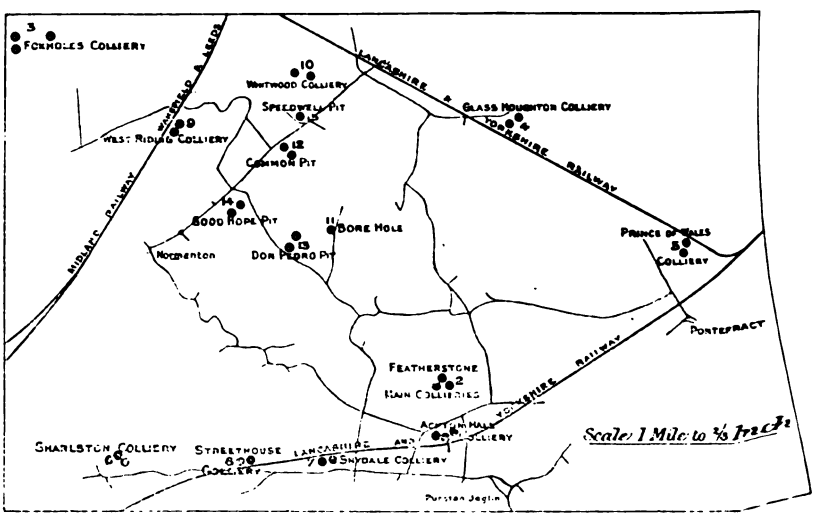


Fig. 1.—Plan showing the position of collieries in the vicinity of Pontefract.

The sinking at the Ackton Hall colliery was practically dry, the only water of any quantity being met with at a depth of 210 feet; it was kept back with cement-walling and a watertight curb, rendering the shaft

below that point absolutely dry. The water is collected in water-lodges, and pumped to the surface by an electrically worked three-throw horizontal pump, and is used for feeding the boilers.

The pit is 18 feet in diameter, and is lined throughout with 10 inches of brick-work, set in mortar, resting on thirty 14 inches cast-iron curbs, having an average distance between them of 180 feet. There are 7 watertight curbs, which are more carefully wedged at the back than the others, although, as a matter of fact, any one of the curbs in the pit is sufficient to keep back a moderate amount of water.

The principal coal-seams met with in the sinking are the Stanley Main, at a depth of 726 feet, the Warren House or Barnsley coal-seam at a depth of 1,000 feet, and the Haigh Moor, at a depth of 1,206½ feet, particulars of which are appended; and the Silkstone coal-seam,* at a depth of 1,724 feet, which was found to be 29 inches thick. There are besides these coal-seams two, if not others, which may prove to be workable, namely, the Mapplewell, at a depth of 837 feet; the shale coal-seam, at a depth of 669 feet, which is of excellent quality, but only about 2 feet thick; and possibly the Beeston, which lies about 400 feet below the Silkstone coal-seam.

In the majority of pits in this neighbourhood the Silkstone four feet, or Johnny coal-seam, is found 100 to 120 feet above the Silkstone coal-seam, and to this circumstance the writer would like to draw special attention, as it has been the cause of the expenditure of a large sum of money. The Haigh Moor coal-seam was found to exist at a depth of 1,206½ feet, and the Silkstone coal-seam in this district occurs at 500 to 600 feet below, with, as has been mentioned, the Johnny or Silkstone four feet coal-seam some 100 feet above it, the two seams being worked at some collieries in the neighbourhood.

When the sinking had proceeded to a depth of 1,724 feet, a coal-seam was met with 29 inches thick, of fair quality, but not in appearance like the Silkstone coal-seam, there being an absence of the usual "hards" which are always present in it. The sinking was pushed on, and it was expected daily that the true Silkstone coal-seam would be found. No seam of importance, however, was discovered, and a bore-hole was put down with some difficulty, owing to the strata being exceptionally hard, to a depth of over 90 feet. Still no coal could be found. The only seam which was passed through was supposed to be about 17 inches thick. When the bore-hole with the appliances at hand had been put down to as great a depth as possible sinking was recommenced, and at a depth of 1,808½

* The so-called Silkstone coal-seam is the same as the Middleton main coal-seam.

feet from the surface the coal-seam passed through in the bore-hole was proved. It was found to be 18 inches thick, and seemed of excellent quality, not unlike the Silkstone "softs." All engineers were agreed that this was the wrong sort for the Silkstone coal-seam, and its thinness was the cause of great disappointment. It was, however, decided to push the sinking forward to the Beeston coal-seam, which, at a distance of about 4 miles from Ackton Hall colliery, is found (300 feet below the Silkstone coal-seam) of good quality and 4 feet thick. The sinking proceeded to a depth of 2,126 feet from the surface, reached in November, 1894, with the result that a coal-seam was found in appearance like the Beeston, but only 17 inches thick.

The writer appends a section of the strata passed through below the Haigh Moor coal-seam, at a depth of 1,206½ feet, to the bottom of the shaft, and from this it will be seen that several thin coal-seams were found.

The question then arose as to which of these was the Silkstone and which the Beeston coal-seam. As this latter was supposed to be 300 feet below the Silkstone coal-seam, and the latter seam from 500 to 600 feet below the Haigh Moor, it was supposed that the seam 18 inches thick, at a depth of 1,808½ feet, was the proper seam, and not having found any coal-seam above 24 inches in thickness below that point, it was decided to abandon for a time any idea of working the Beeston coal-seam, and operations were confined to driving in the Silkstone, in the hope of finding the coal-seam thicken.

A temporary landing was fixed at this depth, 1,808 feet from the surface, a single cage was put into the shaft, and two roads were started away from the pit going towards the north and south respectively. When these places had proceeded about 150 feet, roadways were also started east and west, the latter, however, only being proceeded with for a short distance. The two roads to the north and south were advanced to a distance of 900 feet, and no alteration was found in the thickness of the seam or in the nature of the coal, which maintained an average thickness of 17 inches throughout. Having reached this distance on the north side of the shaft without any result, it was thought advisable to put up a trial bore-hole in the roof and endeavour to find the coal, which in the shaft was proved to exist ahout 90 feet higher up. Accordingly, a pit (6 by 5 feet) was driven vertically upwards, and on reaching the level where in the shaft the 29 inches coal-seam had been passed through, a good seam of coal was found, in all appearance like the true Silkstone, and of the following section :—

	Feet.	Inches.
Coal	1	5
Dirt	1	2
Coal	3	6

Meanwhile, it should be mentioned that during the time of the driving of the roads above referred to, sinking operations had been proceeding at the neighbouring Prince of Wales colliery, near Pontefract, and a good seam of Silkstone coal had been found at a depth of 508 feet below the Haigh Moor, which fact tended to prove that the seam now discovered was in all probability the true seam, and that it was owing to the fact that in the shaft the seam had only measured 29 inches thick, as well as to the supposition of the existence of the Silkstone four feet or the Johnny coal-seam that so much time and money had been spent in proving the thin seam, which was found at a depth of 1,808½ feet.

It has been noted recently that at the depth of 1,710 feet from the surface there appears in the shaft some slight dislocation of the strata. This dislocation does not amount in any sense to a fault, but at one side of the shaft a small seam of cannel coal appears some 15 inches thick, whilst at the other side of the shaft this runs out to nothing. This fact seems to point to a disturbance of the strata about this point, and may account for the seam being so thin. The seam at a depth of 1,808½ feet has now been abandoned altogether, and attention has been turned to driving in the seam laying 90 feet above that point, as in all probability this is the seam which was being sought for. Little or nothing has been done except to prove the existence of a thicker seam than exists in the shaft at a point some 900 feet to the north of the pit, whilst at a similar distance on the south side, as far as one can judge, there seem to be two seams about 2 feet in thickness, some 13 or 14 feet apart. Both these seams appear to be of good quality, the upper one especially so, and the writer thinks that the latter could in any case be worked to a profit.

It may be mentioned that the sinking has been conducted throughout without any serious accident. The only fatal accident which occurred was of a very extraordinary nature; the facts are as follows:—A sinker was holding the drill in the ordinary manner between his legs, and two others striking at it, when a small piece of steel flew off the end of the drill and entered the man's heart, causing his death in a few moments.

During the latter part of the sinking operations, the engineman on one occasion overwound the kibble containing four men, but as there was a safety-hook on the rope the latter was detached, and the men escaped with nothing worse than a severe shaking.

The walling-scaffold was in every case hung by chains from hooks fixed into the side of the shaft, which were moved down from time to time as required. Six chains have been used in suspending the scaffold in two halves, and the system has been found to work admirably. From a depth of 1,050 feet from the surface the sinking has been completed with the permanent winding-engine, which was found very convenient. The Foulstone centre-line apparatus has been used in the sinking, and proved handy and successful. Elliott locked-coil ropes were used, and owing to their non-twisting properties they were particularly valuable during the sinking.

In writing this account of the sinking at Ackton Hall colliery the writer does not claim to have given a detailed account of the operations during the sinking, but trusts that the few remarks with regard to the thinning out of the coal-seams (for the working of which the pit was originally sunk) may be of interest to the members.

APPENDIX A.—SECTION OF STRATA SUNK THROUGH AT THE ACKTON HALL COLLIERY, FEATHERSTONE, FROM THE HAIGH MOOR COAL-SEAM DOWN TO THE BEESTON COAL-SEAM.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
244	Clod	4	5	1,198	3
	Haigh Moor Seam.				
245	**COAL**, best ...	3	3	1,201	6
246	Dirt, bearing ...	1	9	1,203	3
247	**COAL**, seconds	1	1	1,204	4
248	Dirt, soft spavin	0	8½	1,205	0½
249	**COAL**, seconds	1	7	1,206	7½
250	Soft clunch with **COAL** streaks	0	4½	1,207	0
251	Stone clunch ...	6	10	1,213	10
252	**COAL**	0	4	1,214	2
253	Soft spavin ...	0	11	1,215	1
254	Cank	0	7	1,215	8
255	Stone clunch ...	3	6	1,219	2
256	Strong stone bind	2	3	1,221	5
257	Strong stone bind	8	4	1,229	9
258	Black bind ...	4	8	1,234	5
259	Blue bind ...	2	6	1,236	11
260	Stone bind and rock bands ...	4	10	1,241	9
261	Stone bind with ironstone balls	10	8	1,252	5
262	Grey bind ...	7	6	1,259	11
263	Clunch	0	6	1,260	5
264	Grey bind ...	0	5	1,260	10
265	Soft spavin with streaks of **COAL**	0	9	1,261	7
266	Clunch	4	3	1,265	10
267	**COAL**, good ...	2	4	1,268	2
268	Black spavin ...	0	3	1,268	5
269	Clunch	8	0	1,276	5
270	Very strong stone bind	49	0	1,325	5
271	Rock and cank ...	33	10	1,359	3
272	Blue bind ...	10	7	1,369	10
273	Clunch	8	11	1,378	9
274	Stone bind and rock bands ...	32	8	1,411	5
275	Cank	2	0	1,413	5
276	Stone bind and rock band ...	7	6	1,420	11
277	Stone bind ...	3	10	1,424	9
278	Black bind ...	3	8	1,428	5
279	Clunch with mussel-shale partings ..	1	9	1,430	2
280	Stone bind ...	11	1	1,441	3
281	Blue bind ...	6	5	1,447	8
282	Black bind and ironstone ...	5	6	1,453	2
283	**COAL**, good ...	1	8	1,454	10
284	Soft spavin ...	0	5	1,455	3
285	Clunch	1	3	1,456	6
286	**COAL**	0	0½	1,456	6½
287	Clunch	0	1½	1,456	8
288	**COAL**	1	4½	1,458	0½
289	Soft clunch ...	1	3½	1,459	4
290	Strong clunch ...	3	4	1,462	8
291	Strong grey bind	12	7	1,475	3
292	Grey rock ...	0	3	1,475	6
293	Clunch	1	2	1,476	8
294	Stone bind ...	3	5	1,480	1
295	Clunch	1	3½	1,481	4½

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
296	Strong stone clunch	2	10	1,484	2½
297	Stone bind ...	10	2	1,494	4½
298	**COAL**	1	1	1,495	5½
299	Black bat and **COAL** mixed...	0	3	1,495	8½
300	Spavin and **COAL** mixed	0	8	1,496	4½
301	Clunch	2	0	1,498	4½
302	Strong stone clunch	3	0	1,501	4½
303	Stone bind mixed with rock bands	14	10	1,516	2½
304	Grey and canky rock	14	3	1,530	5½
305	Rock mixed with stone bind ...	4	1	1,534	6½
306	Stone bind ...	6	7	1,541	1½
307	Grey rock ...	1	0	1,542	1½
308	**COAL**	0	8	1,542	9½
309	Clunch	1	2	1,543	11½
310	Stone clunch ...	4	5	1,548	4½
311	Blue bind ...	3	0	1,551	4½
312	**COAL**	0	6	1,551	10½
313	Clunch	3	6	1,555	4½
314	**COAL**	1	10	1,557	2½
315	**COAL** mixed with dirt	1	4	1,558	6½
316	Clunch	5	3	1,563	9½
317	Grey canky rock	2	11	1,566	8½
318	Stone bind ...	8	4	1,575	0½
319	**COAL**	1	0	1,576	0½
320	Black bat ...	0	1½	1,576	2
321	Clunch	6	2½	1,582	4½
322	Strong stone bind	16	6	1,598	10½
323	Grey rock ...	2	1	1,600	11½
324	Hard rock mixed with stone bind	1	0	1,601	11½
325	Strong grey rock	0	7	1,602	6½
326	Rock and stone bind	0	9	1,603	3½
327	Hard white rock	5	9	1,609	0½
328	Grey rock, beddy and hard ...	1	4	1,610	4½
329	Clunch mixed with ironstone balls	1	6	1,611	10½
330	Strong grey bind	2	6	1,614	4½
331	Grey clunch and faulty bind ...	16	6	1,630	10½
332	Stone bind ...	20	7	1,651	5½
333	Stone bind ...	5	5	1,656	10½
334	Blue bind ...	15	5	1,672	3½
335	Clunch	2	0	1,674	3½
336	Stone clunch ...	2	2	1,676	5½
337	Stone bind ...	11	0	1,687	5½
338	Dark-coloured bind	1	3	1,688	8½
339	Grey rock ...	8	7	1,697	3½
340	Dark blue bind and ironstone ...	6	3	1,703	6½
341	**COAL**	0	8½	1,704	3
342	Clunch	0	3½	1,704	6½
343	**COAL** mixed with dirt	0	4	1,704	10½
344	Black bind ...	4	6	1,709	4½
345	**CANNEL COAL**, bastard ...	0	4	1,709	8½
346	Clunch	3	6	1,713	2½
347	Dark bind ...	2	8	1,715	10½
348	Dark blue bind ...	3	4	1,719	2½
349	Black bind, mixed with streaks of **COAL** ...	2	8	1,721	10½
350	**COAL**, good, *Silkstone Coal-seam*	2	5	1,724	3½
351	Spavin	0	8	1,724	11½
352	Clunch	2	0	1,726	11½
353	**COAL**	0	5	1,727	4½
354	Dirt	0	2	1,727	6½
355	**COAL**	0	10	1,728	4½
356	Dirt	0	1	1,728	5½
357	**COAL**	0	3	1,728	8½
358	Strong stone clunch	1	0	1,729	8½
359	Grey rock ...	1	0	1,730	8½
360	Stone bind ...	4	1	1,734	9½
361	Grey rock ...	0	10	1,735	7½
362	Blue bind ...	7	10	1,743	5½
363	Black bind ...	1	0	1,744	5½
364	**COAL**	1	1	1,745	6½
365	Clunch	2	0	1,747	6½
366	Blue bind ...	4	10	1,752	4½
367	Stone bind and rock bands ...	4	11	1,757	3½
368	Stone bind ...	7	5	1,764	8½
369	Cank stone ...	1	6	1,766	2½
370	Stone bind ...	3	8	1,769	10½
371	Blue bind ...	2	8	1,772	6½
372	Blue bind ...	15	6	1,788	0½
373	Dark-coloured clunch, mixed with ironstone balls	2	10	1,790	10½
374	Blue bind ...	7	3	1,798	1½
375	Black shale ...	0	9½	1,798	11
376	**COAL**	0	4½	1,799	3½
377	Clunch	7	9½	1,807	1
378	**COAL**, soft and good (supposed *Silkstone Coal-seam*)	1	5½	1,808	6½
379	Spavin	1	4½	1,809	11
380	**COAL**	0	2½	1,810	1½
381	**COAL**, mixed with dirt ...	0	1	1,810	2½
382	Stone clunch, very hard	1	1	1,811	3½
383	**COAL**, mixed with dirt ...	0	1½	1,811	5
384	Stone clunch, very hard	1	3½	1,812	8½
385	Grey rock, very hard	1	10	1,814	6½
386	Stone bind, very hard	1	6	1,816	0½
387	Grey rock, very hard	3	4	1,819	4½

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
388	Rock bands, mixed with stone bind	5	11	1,825	3½
389	Grey bind ...	1	2	1,826	5½
390	Blue bind ...	13	8	1,840	1½
391	Clunch, strong ...	3	1	1,843	2½
392	**COAL**	0	1½	1,843	4
393	Clunch	1	9½	1,845	1½
394	Rock, white and hard	14	11	1,860	0½
395	Grey bind, strong	15	8	1,875	8½
396	Cockle-shell bed...	0	3	1,875	11½
397	Black bind ...	0	3	1,876	2½
398	Grey bind and ironstone ...	4	9	1,880	11½
399	Soft clunch ...	1	7	1,882	6½
400	Stone clunch ...	3	2	1,885	8½
401	Rock band, mixed with strong stone	8	1	1,893	9½
402	Grey bind, very strong	7	0	1,900	9½
403	Black bind ...	2	6	1,903	3½
404	**CANNEL COAL**	0	2½	1,903	6
405	Black bind ...	0	5½	1,903	11½
406	Stone bind ..	0	1½	1,904	1
407	Grey bind ...	4	6½	1,908	7½
408	Stone clunch ...	3	11	1,912	6½
409	Grey rock, beddy	10	4	1,922	10½
410	Blue bind ...	7	2	1,930	0½
411	**COAL** (*Blocking Coal-seam?*) ...	2	0½	1,932	1
412	**COAL** and dirt parting ..	0	0¾	1,932	1¾
413	Soft spavin ...	0	4¾	1,932	6½
414	Clunch, disturbed ground in rolls	12	9	1,945	3½
415	Black bind ...	2	5	1,947	8½
416	Black bind ...	1	7	1,949	3½
417	Clunch	1	0	1,950	3½
418	Black bind ...	1	11	1,952	2½
419	Grey bind ...	21	10	1,974	0½
420	**CANNEL COAL**	0	4	1,974	4½
421	Clunch	3	2	1,977	6½
422	Stone bind ...	4	10	1,982	4½
423	**COAL**	0	3½	1,982	8
424	Clunch	1	5½	1,984	1½
425	Grey rock, beddy	5	7	1,989	8½
426	Stone bind, very strong	3	6	1,993	2½
427	Strong blue bind	6	0	1,999	2½
428	Blue bind ...	15	6	2,014	8½
429	Black bind mixed with ironstone balls	3	0	2,017	8½
430	Dark-coloured blue bind	1	6	2,019	2½
431	**COAL**	0	2	2,019	4½
432	Black bat ...	0	1	2,019	5½
433	Clunch, strong ...	19	9	2,039	2½
434	Grey stone bind...	25	10	2,065	0½
435	Grey rock ...	1	9	2,066	9½
436	Rock mixed with stone bind and clunch, varying in thickness and irregular on bed; the beds of rock varied in thickness from 3 to 36 inches between the partings ...	39	1	2,105	10½
437	Blue bind ...	10	10	2,116	8½
438	Black shale ...	1	9	2,118	5½
439	**COAL**	0	2	2,118	7½
440	Dark-coloured clunch	1	8	2,120	3½
441	Light-coloured clunch	4	6	2,124	9½
442	**COAL** (*Beeston Coal-seam*) ...	1	5	2,126	2½
443	Dark-coloured clunch	2	6	2,128	8½
444	**COAL**	0	1½	2,128	10
445	Clunch	9	4½	2,138	2½
446	**COAL**	0	3½	2,138	6
447	Spavin	0	2½	2,138	8½
448	Clunch	1	6	2,140	2½
449	Rock, beddy ...	1	6	2,141	8½
450	Rock bottom ...	2	2	2,143	10½

Appendix B.—Depth of Curbs at the Ackton Hall Colliery, Featherstone.

No. of Curb.	Description.	Depth from Surface. Ft.	In.
19	dry	1,221	5
20	dry	1,359	3
21	dry	1,420	11
22	dry	1,494	4½
23	dry	1,555	4½
24	dry	1,651	5½
25	dry	1,716	1
26	dry	1,772	6½
27	dry	1,875	8½
28	dry	1,947	8½
29	dry	1,999	2½
30	dry	2,141	8½

PPENDIX C.—DEPTHS TO COAL-SEAMS BEING WORKED IN THE VICINITY OF PONTEFRACT.

No. on Map, Fig. 1.	Names of Collieries and Pits.	Depths to Seams.	Coal-seams Worked.
		Feet.	
1	Ackton Hall	1,206	Haigh Moor.
	,, ...	1,724	Silkstone.
2	Featherstone Main	714	Stanley Main.
	,, ...	1,200	Haigh Moor.
3	Foxholes	150	Warren House.
	,, ...	390	Haigh Moor.
4	Glass Houghton	522	Stanley Main.
	,, ...	744	Warren House.
	,, ...	1,026	Haigh Moor.
5	Prince of Wales	1,398	Haigh Moor.
	,, ,, ...	1,906	Silkstone.
6	Sharlston	1,005	Stanley Main.
	,, ...	1,260	Warren House.
	,, ...	1,515	Haigh Moor.
7	Snydale	657	Stanley Main.
	,, ...	1,280	Haigh Moor.
8	Street House	690	Stanley Main.
9	West Riding	231	,, ,,
	,, ...	678	Haigh Moor.
	,, ...	1,245	Silkstone.
10	Whitwood	735	Haigh Moor.
	,, ...	1,320	Silkstone.
11	,, Borehole ...	381	Stanley Main.
12	,, Common Pit ...	210	,, ,,
13	,, Don Pedro Pit...	459	,, ,,
14	,, Good Hope Pit	210	,, ,,
15	,, Speedwell Pit ...	177	,, ,,

NDIX D.—SECTION OF STRATA SUNK THROUGH, NEAR THE SILKSTONE COAL-SEAM, AT THE PRINCE OF WALES COLLIERY, PONTEFRACT.

Description of Strata.	Thickness of Strata. Ft.	Ins.
rong stone	7	0
ɔne bind	12	0
ack shale	1	6
ıssel bed	2	3
ɔne bind	3	6
ıssel bed	2	0
ıe bind	5	0
ɔnstone	0	2½
ıe bind	3	8
ack shale	2	0
OAL	0	1½
avin	0	4
rk bind	8	0

No.	Description of Strata.	Thickness of Strata. Ft.	Ins.
14	Mussel bed	0	5
15	Dark grey bind	9	0
16	Black shale	0	6
17	Stone bind	4	0
18	White stone	9	0
19	Stone bind	9	0
20	Strong bind, with iron-stone	8	7
21	Black shale	1	0
	Silkstone Coal-seam—		
22	**COAL**, good	3	0
23	Dirt	0	3
24	**COAL**, good	1	2

[r. H. ST. JOHN DURNFORD, replying to numerous questions, said ıo workings had been made from the shaft in the coal-seam at 1,724 but a landing was now being put in. The Silkstone coal-seam had

been found of a better section to the north of the shaft, and it seemed to be of a better section to the south. The colliery 2 miles to the north-east has a good Silkstone seam, but at Sharlston colliery, 2 miles to the west, the seam was doubtful, and was not being worked. South Kirkby colliery lies southwards, but the pit is only sunk to the Swallow-wood coal-seam, and the Silkstone coal-seam has not been proved further south than Ackton Hall colliery. Newland colliery was further north. The nearest point at which the Silkstone coal-seam was worked was Whitwood colliery.

The PRESIDENT said that good Silkstone coal was found on the railway from Normanton to York. It was good at the West Riding collieries. Whitwood colliery had a good Silkstone, and it was fair at Wheldale and Frystone collieries. The seam had been worked as the Middleton main coal-seam to the north and west, and it seemed as if Ackton Hall colliery was just on the border where the seam was splitting. More evidence would be forthcoming as explorations were made in the coal-seam at Ackton Hall colliery.

Mr. DURNFORD said that the seam of cannel found in the shaft was very valuable, and was 1 foot thick.

Mr. W. HOOLE CHAMBERS (Tankersley colliery) said at Silkstone Main colliery, situated near Barnsley, there was a dirt in the Silkstone coal-seam, 14 inches below the usual dirt, which was 9 inches thick. It commenced by a dirt parting, and increased to 27 feet in thickness, dividing the bottom part of the seam from the top. It seemed as if something similar had taken place at Ackton Hall colliery.

Mr. DURNFORD said that the Silkstone coal-seam varied greatly at Bower's Allerton colliery, and it was also split. The coal—the Silkstone seam—now traced was "hards." He had not been able to recognize the whetstones coal—it would not be easy in a hole 5 feet square.

Mr. W. HOOLE CHAMBERS said that at Tankersley colliery, the Silkstone seam was 5 feet thick with 5 inches of dirt. At the Norfolk pit it, the top portion only was worked; the bottom portion was divided by dirt several feet thick. At collieries working nearer Sheffield, the Silkstone seam was of the proper thickness, but for a mile or more at the Thorncliffe collieries only the top portion was being worked.

The PRESIDENT said that at Aldwarke collieries the Silkstone seam was split into two seams, about 60 feet apart.

Mr. W. HOOLE CHAMBERS said that at the Thorncliffe collieries the new or middle dirt increased in thickness, and the old dirt remained of the same thickness.

DURNFORD, replying to further questions, said that the seam
ı the staple had a good blue bind roof. No workable coal-seam
n found between the Haigh Moor and this seam. He had not
le to identify the Flockton and brown metal coal-seams. The
coal-seam had been identified.

W. HOOLE CHAMBERS suggested that the Beeston appeared to be
nmoor of South Yorkshire, but it seemed to be of different quality.
hinmoor seam at the Thorncliffe collieries had a considerable
of small bands of dirt in it, but was a coal of very good quality.

PRESIDENT said that a seam called the Middleton little coal was
bout 60 feet above the Middleton main coal-seam in the west;
good locomotive coal, 2½ to 3 feet thick. It was a workable
ful seam at Morley and Ardsley collieries. He did not know
came of it east of Leeds. Lofthouse colliery would be furthest
ast of those working it. The Beeston coal-seam north and east
ls was a very good seam, and was largely worked at Garforth,
ield, and Bower's Allerton collieries. It began to split about
ll, west of Leeds, where there was the Churwell thick and the
ll thin coal-seam. Further west it was called the Shirtcliffe coal-
nd was split into two or three seams, which were very irregular.
Morley district, these seams were within a few feet of each other,
he Dewsbury district they were 20 to 50 feet apart. About Cleck-
at one place, one of these seams was a fair cannel coal. About
t above the Beeston and 150 feet below the Middleton main coal-
ı the district from Emley to Cleckheaton is the blocking coal-seam,
uality, and from 1½ to 2 feet thick. He thought that the upper coal
ad been found in the rise pit, was the same as the Middleton main
m, or what was called the Silkstone in West Yorkshire. One of
ns below would probably represent the blocking coal-seam, which
to be in the same position in the measures as the Silkstone
m of South Yorkshire, but it was of inferior thickness and of
ality. The Middleton main took the economic place of the
ıe coal-seam, whether or not it took the same place in the strata.

DURNFORD said that at Ackton Hall colliery the blocking coal-
as 135 feet below the Silkstone or Middleton main coal-seam,
ut half-way between that and the Beeston coal-seam.

PRESIDENT said that at Mirfield colliery, the Beeston was 210 feet
he blocking coal-seam, and 360 feet below the Middleton main

coal-seam; this agreed very fairly with the Ackton Hall colliery section from the upper seam. He had no doubt that the upper coal-seam was the Middleton main. The seam in the lower part of the section would represent the blocking coal, and the other one, met at 1,808½ feet, would represent the Wheatley lime coal-seam, which lies between the Middleton main and the blocking coal-seams.

Mr. NASH moved a vote of thanks to Mr. Durnford for his paper. The district was practically unproved below the Middleton main and Haigh Moor coal-seams, and this paper might assist members in deciding as to whether they could expect these seams to be workable in that part of the county.

Mr. G. BLAKE WALKER seconded the motion.

The motion was carried, and the discussion was adjourned.

DISCUSSION ON PROF. LEWES' PAPER ON "MINING EXPLOSIVES."*

Mr. G. BLAKE WALKER said that Prof. Lewes made a statement which struck him with great force in connexion with the explosion at Blackwell colliery.† In dealing with ordinary blasting-powder as an unsuitable explosive for use in mines, Prof. Lewes pointed out that one resulting constituent of its explosion was carbon monoxide. He thought that attention had not previously been drawn to the fact that carbon monoxide was an explosive gas. Prof. Lewes stated that the presence of a small percentage of carbon monoxide in an atmosphere such as would result from the discharge of a heavy shot of blasting-powder would produce the same effect in the atmosphere as if a small portion of fire-damp was present, and if so it would explain the occurrence of an explosion where no trace of fire-damp could be found in the atmosphere, either before or after the explosion took place. If, therefore, in some mine which was dry and dusty, a heavy shot of blasting-powder were fired, and the shot was blown out, carbon monoxide would be produced and mixed with an atmosphere full of particles of fine coal-dust. Prof. Lewes said that the conditions of an explosion existed which would be continued wherever dust existed to spread it.

* *Trans. Fed. Inst.*, vol. ix., page 320. † *Ibid.*, page 322.

The PRESIDENT asked if Mr. Walker thought that Prof. Lewes was correct in saying that traces of carbon monoxide would make a mixture of coal-dust and air very explosive?

Mr. WALKER said that Prof. Lewes' statement was as follows:—

Experiments which have been made upon the effects of fire-damp and dust combined in causing colliery explosions show conclusively that even when fire-damp is present in such minute quantities as to form a mixture very far removed from the point of explosion, it makes the mixture of coal-dust and air highly explosive. Traces of carbon monoxide will do exactly the same thing when the air is laden with coal-dust, whilst the temperature of ignition is lower than with methane; so that when the air of the mine is charged with coal-dust, the probabilities are that a very large volume of explosive mixture is formed by the rapid escape of the products of combustion into the dust-laden air, and this (being ignited either by the flame or by red-hot solid products driven out into it by a blown-out shot) initiates a considerable area of explosion.*

The PRESIDENT said that the deduction drawn by Prof. Lewes was that no explosive, which gave off carbon monoxide as one of the products of combustion, should be used in mines.

Mr. H. B. NASH asked, if Prof. Lewes' theory was correct, how it was that in all experiments made with coal-dust alone the same result had not taken place? Since the Blackwell explosion, Mr. Rhodes had told him that in his experiments with various coal-dusts he had never been able to get up a coal-dust explosion in his apparatus, but if the smallest mixture of fire-damp was added an explosion ensued. With coal-dust alone Mr. Rhodes had never been able to get an explosion. If a blown-out shot from a low explosive like blasting-powder had been charged with carbon monoxide, why did it not give Mr. Rhodes the same result there as Prof. Lewes has found in his experiments?

Mr. WALKER asked whether Mr. Rhodes had experimented with blasting-powder? The experiments were made with high explosives, and Mr. Rhodes would regard blasting-powder as outside the scope of his inquiry.

Mr. NASH said he understood that Mr. Rhodes used blasting-powder.

Mr. WALKER said an interesting point was mentioned in the *Report*† of the Flameless Explosives Committee of the North of England Institute of Mining and Mechanical Engineers as to the difference in the behaviour of an explosive in manufactured gas and mine gas. In the Hebburn experiments, they used natural gas from the pit and from the mains of the gas company, and the difference in the behaviour of an explosive was very marked.

* *Trans. Fed. Inst.*, vol. ix., page 322. † Page 36.

Mr. NASH said that if they got carbon monoxide from an overcharged shot in the mine, they ought also to get it in a shot without tamping in the experiments at Hebburn colliery.

Mr. WALKER said, according to that theory, the Blackwell explosion was caused by a powder shot, and if Prof. Lewes' theory was correct he gave an explanation of an otherwise insoluble mystery.

Mr. NASH said that the explosion was not an insoluble mystery according to Mr. Donald Stuart, who had a theory which to his own mind explained it satisfactorily, whether it did so or not to other people.

Mr. WALKER said that he had not read Mr. Donald Stuart's book, but Prof. Lewes' theory afforded an explanation of the Blackwell explosion. It might not be the correct one, but it appeared to be certain that no gas was found before or after the explosion. Mr. Stokes and other inspectors of mines had failed to find gas in the mine; there was no evidence of any, and yet an explosion occurred in a pit where the coal was far from bituminous.

The PRESIDENT said that, as far as could be learned from the reports in the newspapers, the Blackwell seemed to have been on all fours with the Seaham explosion. A shot was fired in an old road which had been driven twenty years, and there would be a great deal of dust in various places.

Mr. WALKER said that the Blackwell explosion cast a side light on the Camerton explosion, where no gas had ever been found.

Mr NASH said that it appeared desirable that experiments should be made with carbon monoxide mixed with air and coal-dust to ascertain whether an explosion would be initiated.

The PRESIDENT said the experiment of firing into coal-dust had been repeatedly tried, but the question was what would be the conduct of carbon monoxide placed in it? If carbon monoxide could be mixed with the air and an explosive fired into it, and the result compared with a similar shot fired without the carbon monoxide, they would know what value to place on the presence of carbon monoxide.

Mr. A. A. ATKINSON (Barrow collieries) asked if Prof. Lewes had got an explosion from a certain preparation of carbon monoxide and coal-dust?

Mr. WALKER stated that Prof. Lewes said that the conditions under which methane, the essential constituent of fire-damp, would produce an explosion applied equally to carbon monoxide.

Mr. M. WALTON BROWN wrote that Prof. Lewes, when he read his aper, showed clearly that traces of carbon monoxide rendered mixtures f coal-dust and air explosive. Prof. Lewes ignited a small weight of arbonite in a closed bomb, a part of the resulting gas (40 per cent. of hich consisted of carbon monoxide) was mixed with air in a small gas eceiver, and the gaseous mixture did not ignite on the application of lighted match. A similar gaseous mixture was formed, and coal-dust eing sprinkled into it, the whole was readily ignited by a lighted match.

Prof. VIVIAN B. LEWES wrote that experiments which he made early n 1895 showed clearly that carbon monoxide, when added even in small uantities to a dust-laden atmosphere, caused it to become highly explo- ive; and it was evident, under these conditions, that carbon monoxide layed the same part as marsh-gas in similar mixtures of dust-laden ir and fire-damp. This observation seemed to him to be so important, n view of the presence of this gas in the products of combustion of many xplosives, that he gladly took the opportunity afforded him of bringing t forward. He had intended to make a number of experiments in order o determine the exact quantity of carbon monoxide needed to make a ust-laden atmosphere explosive, but unfortunately stress of other work revented him doing this. He, however, satisfied himself that the pro- ucts of the combustion of many blasting explosives in use in mines ould produce exactly the same effect as pure carbon monoxide. He hought that it was most important that experiments should be made with arbon monoxide mixed with air and coal-dust, and should any member of he Institution have it in his power to make such experiments, he would e delighted to do everything he could to aid in carrying out such experi- nents.

DISCUSSION ON MR. RANKIN KENNEDY'S PAPER ON "ELECTRICAL MACHINERY FOR MINES."*

Mr. T. B. A. CLARKE (Tankersley) said he should like to see some ests of the machines Mr. Kennedy had described, as they were based on rinciples different from any machines built in Great Britain, and there eemed to be no absolute test of any motors of that type. Mr. Kennedy tated that the motors were suitable for driving coal-cutting, and holing achinery. He had experimented with alternating-current motors, and had been an obstacle to their use that they would not start under

* *Trans. Fed. Inst.*, vol. x., page 98.

varying or heavy loads. He would also like to know whether the Kennedy motors could be worked at, say, 500 volts. He had always understood that the alternating-current system could only be used at a high pressure, involving the use of a transformer, which was costly and dangerous to use in a mine, as it was impossible to insulate the transformer thoroughly, and when touched it meant instant death. He did not know what attitude the inspectors of mines would take to an alternating-current in a colliery, but thought that they would take some time to think it over before they would sanction its use.

Mr. WALKER understood that Messrs. Crawshaw and Warburton intended to use an alternating-current plant.

The discussion was adjourned.

The meeting then closed.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD ON NOVEMBER 6TH, 1895.

MR. E. B. WAIN, PRESIDENT, IN THE CHAIR.

DEATH OF MR. H. M. LYNAM.

The PRESIDENT alluded to the death of Mr. H. M. Lynam, and proposed that a letter of condolence be sent to Mrs. Lynam and family. Mr. Lynam had, he said, for many years been a most useful member of the Institute, and they would miss his kindly face at their annual gatherings.

Mr. J. RICHARD HAINES seconded the motion, which was passed *nem. con.*

VISIT TO PORT SUNLIGHT.

The members undertook an excursion to Port Sunlight, near Birkenhead, where by permission of Messrs. Lever Brothers, Limited, they went through the Sunlight Soap-works. The visitors were received at the works by Mr. J. Bateman, the engineer and manager, by whom they were conducted through the various departments.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,
HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT,
DECEMBER 16TH, 1895.

MR. E. B. WAIN, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

The report of the Council was read as follows :—

ANNUAL REPORT OF THE COUNCIL.

The Council have pleasure in presenting their Annual Report. Six General Meetings have been held during the past year, at which the following papers were read :—

"Coal Mines Regulation Bill." By Mr. M. Walton Brown.
"Description of the Arrangements at the Maybach Colliery (Germany) for Watering Coal-dust." By Mr. C. Haarmann.
"Gob-fires in Longwall Workings, with Special Reference to the Yard Seam." By Mr. A. Hassam.
"A Modified Form of Longwall Working as applied to Thin Seams of Moderate Inclination." By Mr. John Heath.
"Railway-waggon Axle-boxes and the Mode of Manufacturing them from Steel-plate." By Mr. John Newton.
"Colliery Cost-sheets." By Mr. J. J. Prest.
"Modern Coal-tipplers." By Mr. J. J. Prest.

There were interesting discussions of these and other subjects brought forward.

The Federated Institution of Mining Engineers held their Annual Meeting on September 18th and 19th last, in the large hall of the Shropshire and North Staffordshire Artillery Volunteers, when a large number of interesting and useful papers were read and discussed.

rsions were made to the following places :—Messrs. Doulton's Art ries, Messrs. James MacIntyre & Co.'s Washington Works, the l Colliery, Burslem; the Electric Light Station, Hanley, and tham Hall and Gardens. Our best thanks are due to the various rs of the works and places visited, for their kind hospitality on ccasion.

he number of members on the register is 180, viz. :—

Life Member			1
Honorary Members...			6
Members	120		
Associate Members	2		
Associates	36		
		——	158
Students			15
			180

)uring the year 14 members and 1 student have been elected, the same number have resigned. We also regret that 4 members been lost by death, viz. :—Messrs. W. A. M. Tellwright, Frank , Frederick Wooliscroft, and H. M. Lynam, the loss of whom we all y deplore.

'e likewise refer with deep sympathy to the lamentable accident took place in the early part of the year at the Diglake colliery.

ıe ambulance classes referred to in the last report were well led, upwards of 160 members at the various collieries having ed the examiners. Certificates and medals have been presented by Grace the Duchess of Sutherland. It is sincerely hoped the classes e again continued at the various centres.

ıe mining classes established by the County Council with the eration of this Institute continue to be fairly well attended, and the en and miners generally appear to be taking greater interest in

The Council feel assured that good results will be obtained by ontinuation of this work. The prizes obtained by the successful ıts were distributed by Mr. W. N. Atkinson, the President of The ated Institution of Mining Engineers, on September 7th, at a ttended meeting held at the Town Hall, Stoke-upon-Trent.

[r. T. M. FAVELL moved, and Mr. C. E. DE RANCE seconded, that port be adopted, and this was carried unanimously.

ANNUAL REPORT OF THE FINANCE COMMITTEE.

Your Committee have much pleasure in stating that the income of the Institute for the past year has exceeded the expenditure.

An abstract of the accounts prepared by the Treasurer has already been published and issued, which it is hoped will be considered satisfactory.

As the payments to The Federated Institution of Mining Engineers have to be made in advance, your Committee urge upon the members the necessity of promptly paying their subscriptions.

JOHN STRICK.
WILLIAM HEATH.
ROBERT H. COLE.

The PRESIDENT said that there was an improvement of £50 in subscriptions during the past year, as compared with the previous year. The balance-sheet was made up to July, 1895, and nearly all last year's subscriptions in arrear had been received since that date.

The Finance Committee's report was adopted.

Dr. THE TREASURER IN ACCOUNT WITH THE NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS. **Cr.**

JULY 31ST, 1895.

1894.		£	s.	d.
Oct. 22.—To Balance at Bank		91	17	0
Dec. 13.— „ Amount withdrawn from Longton Building Society and paid into Bank ...	£300 0 0			
„ Interest to Date	5 12 5			
		305	12	5
1895.				
July 31.— „ Members' Subscriptions for the year 1894-95 and Arrears		193	18	9
„ Donation		5	0	0
		£596	8	2

1894.	£	s.	d.
Dec. 21.—By Salaries, 2½ years, to 31st July, 1894, Secretary and Reporter	131	10	0
„ Stamps, Parcels, etc., Secretary's account...	37	8	3
„ Reporter's Expenses	1	5	1
„ Printing, etc.	14	1	7
„ Hire of Rooms	14	7	0
„ Cheque Book	0	5	0
1895.			
Jan. 1.— „ The Federated Institution of Mining Engineers: Balance of Subscription, 1894	22	3	2
Mar. 13.— „ The Federated Institution of Mining Engineers: Subscriptions to 31st July, 1895	156	2	6
July 31.— „ The Federated Institution of Mining Engineers: New Members and Excerpts, 1895	17	10	1
„ Hire of Rooms, 1894-95	13	9	6
„ G. T. Bagguley, Printing, etc.	21	5	4
„ Hughes & Harber, ditto	12	19	4
„ Secretary, Salary and Expenses	49	5	0
„ Reporter, Salary and Expenses	21	13	0
„ Treasurer's Account, Postages	1	5	0
„ Balance	81	18	4
	£596	8	2

The Treasurer in Account with Subscriptions for the Year 1894–95.

July 31st, 1895.

			£	s.	d.
To	130	Members and Associate Members			
Less	1	Life Member			
	129	Members and Associate Members at £2 2s. ...	270	18	0
„	45	Associates at £1 6s.	58	10	0
„	16	Students at 15s. 6d.	12	8	0
„		Donation	5	0	0
			346	16	0
„		Amount overpaid in Subscriptions, 1894–95	0	15	6
			347	11	6
„		Arrears, 1893–94 ... ... £37 0 6			
		Less Struck off as irrecoverable... ... 2 2 0			
			34	18	6
			£382	10	0

			Paid. £	s.	d.	Unpaid. £	s.	d.
By	69	Members and Associate Members paid at £2 2s.	144	18	0			
	59	Do. unpaid £2 2s.				123	18	0
	1	Do. dead				2	2	0
	129							
„	22	Associates paid at £1 6s.	28	12	0			
	23	Do. unpaid at £1 6s. ...				29	18	0
	45							
„	5	Students paid at 15s. 6d.	3	17	6			
	11	Do. unpaid at 15s. 6d.... ...				8	10	6
	16							
„		Donation	5	0	0			
			182	7	6	164	8	6
„		Subscription overpaid 1894–95	0	15	6			
			183	3	0	164	8	6
		Less struck off as irrecoverable, Member deceased				2	2	0
			183	3	0	162	6	6
„		Arrears 1893–94, paid	15	15	9			
„		Do. do. unpaid				21	4	9
			198	18	9	183	11	3
						198	18	9
						£382	10	0

ELECTION OF OFFICERS.

Mr. W. BAILES and Mr. W. L. HOBBS, the scrutineers of the voting-papers, reported the following elections :—

PRESIDENT.

Mr. E. B. WAIN.

VICE-PRESIDENTS.

Mr. W. N. ATKINSON. | Mr. JOHN STRICK. | Mr. JOEL SETTLE.

TREASURER.

Mr. H. R. MAKEPEACE.

SECRETARY.

Mr. J. RICHARD HAINES.

COUNCIL.

Mr. J. C. CADMAN.
Mr. ROBT. HART.
Mr. ARTHUR HASSAM.
Mr. JOHN HEATH.
Mr. JAMES LOCKETT.
Mr. JOHN NEWTON.
Mr. STEPHEN OFFER.
Mr. J. J. PREST.
Mr. FREDK. SILVESTER.
Mr. WILLIAM STATHAM.
Mr. THOS. E. STOREY.
Mr. B. WOODWORTH.

Mr. J. LOCKETT moved, and Mr. HASSAM seconded, a vote of thanks to the officers of the Institute for their valuable services during the past year.

Mr. E. B. WAIN, the re-elected President, then delivered the following address :—

PRESIDENTIAL ADDRESS.

By E. B. WAIN.

It seemed such a short time since I had the honour of addressing you on my election as President a year ago that I felt there was very little to say to-day, except to thank you very heartily for the further mark of confidence you have shown in re-electing me for a second year of office.

It must be a matter of satisfaction to every member of the Institute to know that the steps taken with a view to putting the finances in a more healthy condition have been so successful, and at the same time we regret to learn that a few of our members have resigned in consequence of the alterations made in the interest of the Institute.

The interest shown in our meetings has been well sustained, and the value of the *Transactions* received through our connexion with the other Federated Institutes has been more than maintained.

It is a matter of regret that the year which has passed since the last Annual Meeting has been marked in this district by one of those appalling disasters the prevention of which is one of the first objects of our Institute; but we have the satisfaction of knowing that a most searching enquiry into the cause of the Audley accident showed that no necessary precaution had been neglected by those who had charge of the work.

The depressed condition of trade continues to bear heavily on the coal industry, but there are now more hopeful signs, and I sincerely hope that before our next Annual Meeting we may see a substantial improvement.

Still, we can see that we have still before us the urgent necessity of keeping up with the times, and when we hear that new plants with the most perfect modern appliances to raise from one shaft from 1,600 to 1,800 tons per day in a single shift are being set to work in adjacent coal-fields, we know that it will require every effort which can be put forward to enable the older collieries to compete and hold their own.

The speed of winding in many cases does not now average less than 25 miles per hour, with a maximum of over 40 miles at the middle of the run. It seems doubtful, except for very deep shafts, whether any further improvement in this direction will be possible or desirable as it becomes necessary to increase the output so as to compete with the more modern plants. It may be necessary to raise heavier loads rather than run at excessive speeds. Some advantage will generally be gained by adopting

uble or treble landings, so that each deck of the cage can be changed ultaneously either by hand or power. From a number of examples of h arrangements I find that a time of 10 seconds may be taken as the rage required to change the decks of a two or three-decked cage.

Where we have engines already working at their full power, it will me necessary to make such alterations as will increase their capacity, in this respect we have an excellent example in the work which we an opportunity of inspecting a short time ago at the Sneyd colliery, re the proprietors are fitting the already powerful winding-engine tandem compound cylinders and separate condensers.

Economy of fuel has never been a strong point in colliery work, but fast becoming of vital importance, and the more so as slack coal is ming of more value in the market. With a view to consuming the pest kinds of fuel, coal consumers in the various industries have ted their plant for burning slack coal, and the increased demand for class of fuel has greatly enhanced its value. The old plea that omy of fuel at collieries was of no importance because the material was of little marketable value is now abandoned, and we find colliery neers giving the question their most serious attention. That it is essary to deal with it is shown by the extravagant consumption of el at collieries. It has been estimated that the average fuel consumption of our collieries exceeded 5 per cent. of the output, in some cases aching as high as 10 per cent., whilst one of our best informed thorities (Mr. Emerson Bainbridge) puts it down as low as 2½ per ent. at a well-equipped modern colliery.

The grave importance of this question will be seen when it is membered that a saving of 1 per cent. on the output of a colliery ising 500,000 tons per annum (taking the value of engine fuel as low 2s. 6d. per ton at the pit) is equal to a return of 7½ per cent. on a pital expenditure of £10,000.

Mr. T. Forster Brown puts the probable average consumption of coal r colliery-engines at not less than 6 lbs. per indicated horse-power. As ng ago as 1840 we find records of Cornish engines only using 1·7 lbs. of al per indicated horse-power, whilst a modern high-speed compound ngine will give the same result with the consumption of less than 1½ lbs. f coal.

The extreme variations in load on a colliery winding-engine have been he greatest hindrance to economical working in the past, and the short luration of the run has prevented full advantage being taken of expansive vorking; but I believe that the progressive cut-off gear such as has been

designed by Mr. Ben. Woodworth, and which we hope to hear described shortly, is a thoroughly practical attempt to deal with the difficulty.

We may, I think, reasonably expect that the colliery winding-engine of the future will be a compound condensing engine, working expansively with almost the same economy as the many high-class engines now worked in many other industries, and especially in electric-lighting stations and the Lancashire mills, where the perfection of economy seems to have been reached.

One cause of wasteful steam-consumption in collieries has been the number of engines scattered about the works for various purposes, such as for haulage, pumping, ventilating, screens, and workshops, each probably at some distance from the steam supply, entailing considerable losses due to condensation of steam, in addition to the engine losses.

As the whole of these engines are, as a rule, working continuously with a steady load, there appears to be no reason why the power should not be distributed from a common centre by the application of electric motors.

The development of high-tension alternating-currents is favourable to distribution of power over considerable distances with a maximum of efficiency and minimum of loss in transmission. By such concentration of power there will be a very considerable saving in the engine losses and convenience in application which no other power can give.

For heavy haulage purposes, however, I am of opinion that direct driven endless-rope plants will be found to be more economical, except where the work to be done is at extreme distances from the source of power.

So far, our experience of the application of electricity in this district has been almost exclusively confined to its use for lighting purposes, but we hope shortly to see our local tramway (now worked by steam engines) worked by electric motors, and we shall here, I believe, have a valuable object-lesson in the application of electricity for the generation of power.

Those of you who took the opportunity on our recent visit to Liverpool to inspect the plant of the overhead railway will appreciate the economy with which the power is there applied. The average fuel-consumption with trains averaging over 38 tons in weight, running at a speed of 12 miles per hour, is under 17 lbs. per train mile, with a service of trains every 5 minutes. It is on record that for a period of 6 months 95 per cent. of the trains were punctual to time. The cost for fuel is little over ½d. per train mile, and the whole working cost, including all charges, less than 3½d. per train mile, or 0·1245d. per ton per mile; this is much less than the working cost of the best American elevated railways worked by steam locomotives under similar conditions.

The subject of electric transmission of power is a particularly interesting one, as the time seems to be approaching when every mining engineer must find it necessary to have some knowledge of electricity and its applications, and when a trained electrician will form one of the staff of every important colliery.

I feel, however, that I have already occupied more of your time than I intended, and in conclusion beg to thank you again for your kindness in re-electing me to the important office of your President, and to express a hope that the year before us will be one of progress and continued usefulness for our Institute.

Mr. C. E. DE RANCE moved a vote of thanks to Mr. Wain for his thoroughly practical address, which was seconded by Mr. F. SILVESTER, and carried unanimously.

Mr. B. WOODWORTH read the following paper on "The Woodworth System of Progressive and Automatic Cut-off Gear for Winding-Engines":—

THE WOODWORTH SYSTEM OF PROGRESSIVE AND AUTOMATIC CUT-OFF GEAR FOR WINDING-ENGINES.

By B. WOODWORTH and W. G. COWLISHAW.

In designing expansion-gear for winding-engines it is necessary to provide for conditions totally different from those applicable to ordinary engines. In the first place, it is necessary to provide for starting freely under maximum loads, and for the movements necessary in onsetting and landing the tubs. Secondly, the expansion-gear should be so designed that no loss of speed is experienced, otherwise the advantages of expansive working would be lost. And thirdly, in order to obtain the fullest advantage of expansive working, the expansion-gear should be brought into operation at the earliest possible moment in the winding, and be so proportioned as not to cause any reduction in the speed.

In the opinion of the writers, this object may be obtained by such a gear as is about to be described better than by any gear put into operation by the speed of the engine. Moreover, in the Woodworth gear the point of cut-off is not fixed, but is slightly progressive from start to finish. Thus the first four revolutions take full steam, at the fifth revolution steam is cut off at about 0·50, and at the twenty-first, or last revolution under steam, it is cut off at about 0·30 of the stroke. From the experience gained by four months' working, a saving of steam of at least 35 per cent. has been effected, without in any way interfering with or prolonging the period of the winding. The efficiency of the gear is also clearly proved by the diagrams taken from the engines in the ordinary working, with and without the gear in operation.

The Woodworth gear has been applied at the Sneyd collieries to a horizontal winding-engine with two cylinders, each 36 inches in diameter, with a stroke of 6 feet. The winding-engine works with a pressure of steam of about 85 pounds per square inch, and draws coal from a depth of 1,863 feet. The unbalanced starting load is 125 cwts., and the total load 195 cwts. The drum is 20 feet in diameter, and makes 29 revolutions for each winding. The gear is entirely automatic (but may be put out of action at will by shutting off the supply of steam to a small controlling cylinder), and therefore does not entail any control or attention on the part of the engineman; it is in no way dependent on speed for its effects, and comes automatically into operation at the fifth revolution of the winding.

FIG. 1.

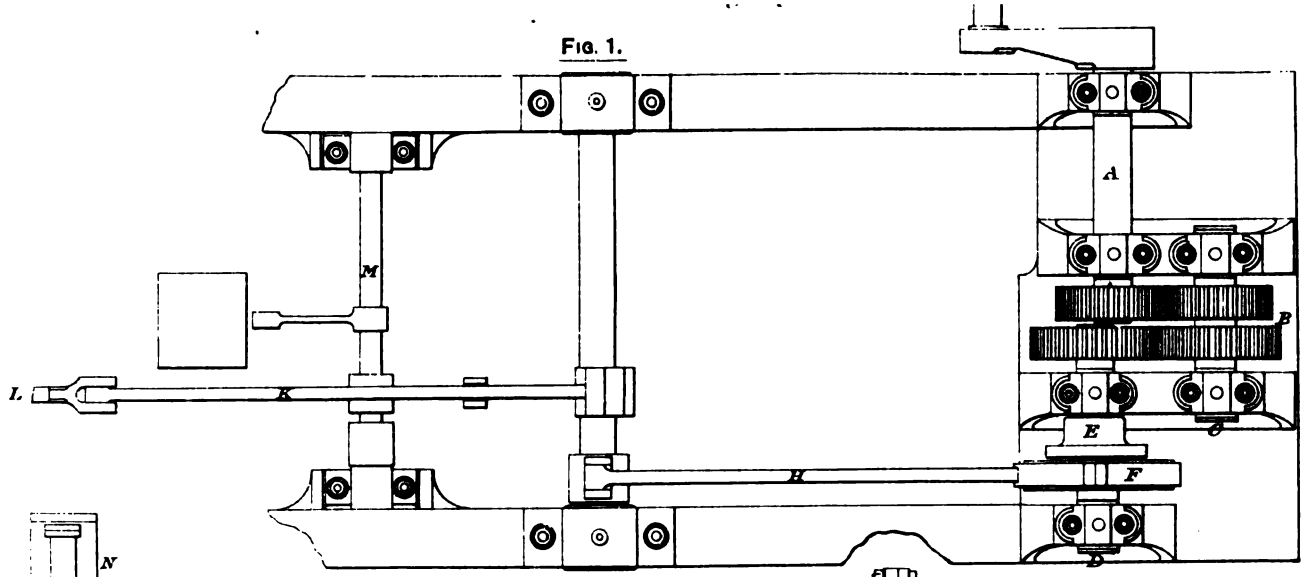
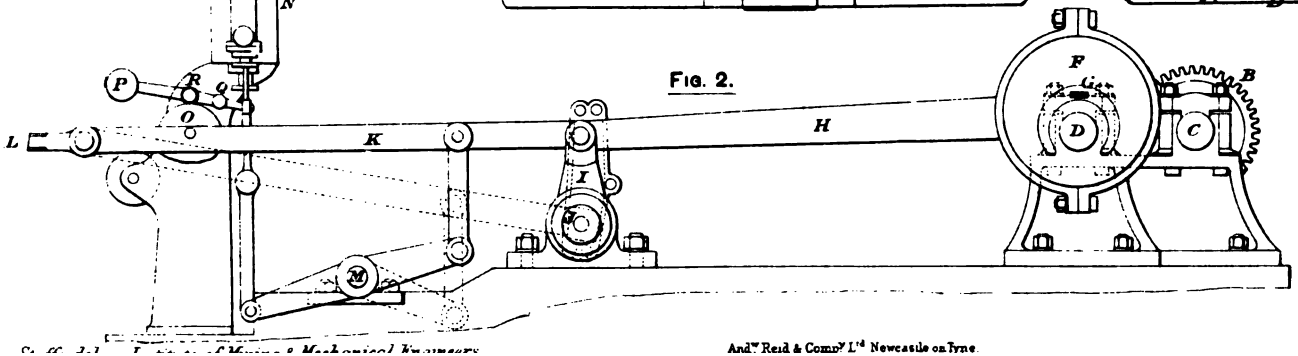
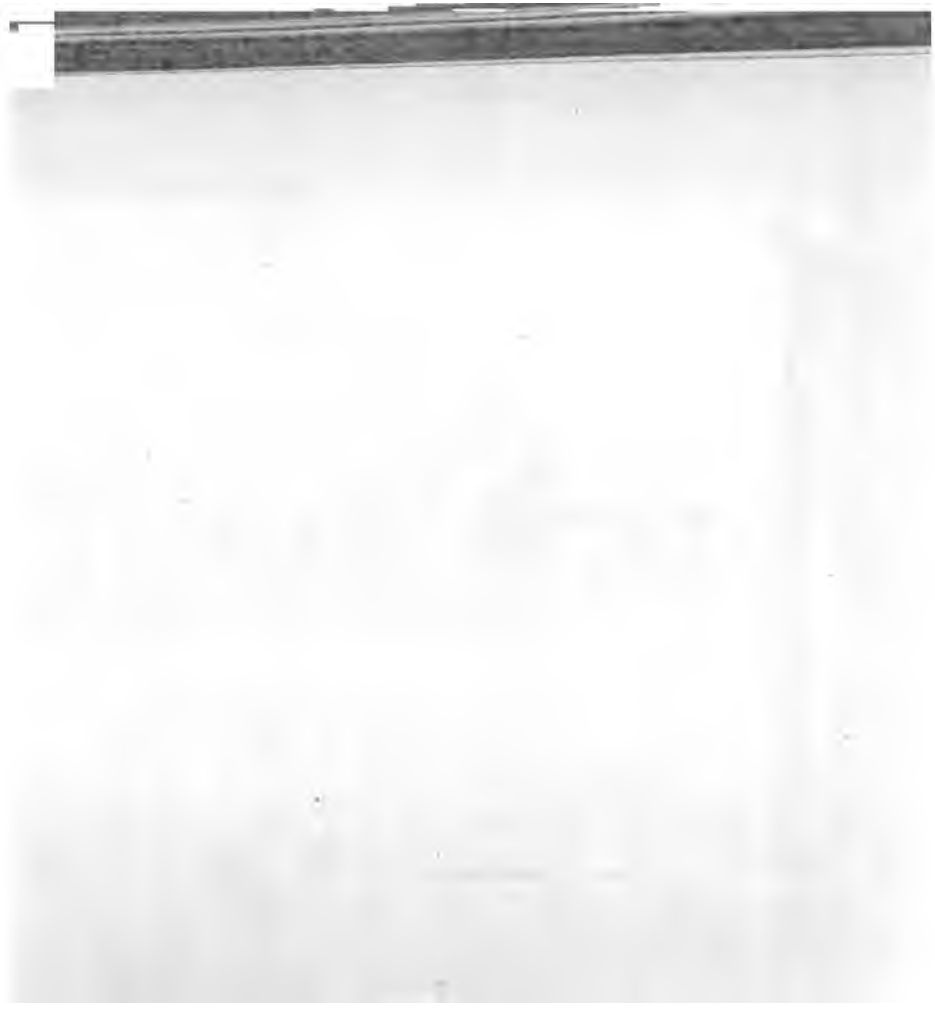


FIG. 2.



And.w Reid & Comp.y L.td Newcastle on Tyne.



In the accompanying drawing (Fig. 1, Plate XVIII.), *A* represents e drum or drag-arm shaft. A train of wheels *B* connects the inter-ediate shaft *C* to the shaft *D*, which carries the cut-off eccentric and iving-gear. *E* is the driving-disc. An ordinary reversing or tumbling centric *F* turns on the shaft. The driving-lug or stud *G* drives the centric *F* in either direction, and its movement operates through the d *H*, the lever or arm *I* in connexion with the rocking shaft *J*, and e latter is provided with a slotted link, which forms part of the rocking aft, and in which works an ordinary block connecting the swing-rod , employed to drive the cut-off valve by means of the spindle *L*.

The train of wheels *B* give a slightly accelerating speed to the shaft , thereby advancing the eccentric *F*, which is driven by the disc *E*; id while the engine runs 29 revolutions for each winding the shaft *D* akes 29½ revolutions, the total advance of the eccentric being about ½ degs., or about 1½ degs. at each revolution.

To put the engine in or out of gear, a small controlling engine ith cylinder *N* is used, working direct by means of a lever the shaft *M*, hich is connected by other levers and links to the swinging-rods *K*, id its movements are controlled as follows, viz. :—The cam *O* is driven r a chain from the shaft *D* through the intervention of bevel and orm-gearing, so that it makes one complete revolution for each inding, and operates the valve of the cylinder *N* through the weighted ver *P* working on the stud-pin *Q*, and in this instance is arranged to eep the cut-off gear out of operation during the first 4 revolutions of ie winding.

The working position is shown by the dark lines, and the dotted lines ow the gear out of operation, with the swing-rods and block-con-exions in their neutral position at the centre of the rocking shaft *J*, hen no movement of the valve takes place. The cut-off valve is full pen when in the central or neutral position.

Although the Sneyd winding-engine is fitted with slide-valves and eparate piston-valves for the cut-off, the writer considers it necessary to id that the Woodworth cut-off gear can be applied to engines with ornish valves driven by either a trip or positive action.

Mr. T. M. FAVELL thought that the Woodworth gear overcame a umber of difficulties which had not been introduced in previous gears. ome gears were put into action at the will of the engineman; others equired a governor to put them into action, at a certain speed of

the engine, and both were objectionable for obvious reasons. The mechanical action of the Woodworth gear would be very much improved if a cataract-cylinder were added (worked with oil or water). At present it was worked by throttling the exhaust steam; this might add something to the cost, but the addition would be small, and the advantages would be very great. The speed of winding was not interfered with, either with or without the gear, and this was a great advantage. He had examined the indicator diagrams, and he found that at starting the winding required an average steam pressure of 60 or 61 lbs. per square inch; when the cut-off gear operated after the fourth stroke the mean pressure dropped to 40 or 42 lbs., and when its action was completed the average steam pressure dropped to 20 lbs. It was proposed to apply a condenser to those engines. He did not see how an application of a condenser to an engine could be satisfactory without the addition of a cut-off like the Woodworth. He believed that it was intended to compound the Sneyd winding-engine; if so, he must point out that the pressure required towards the termination of the winding was 20 lbs. on the high-pressure cylinder; if the low-pressure cylinder was 51 inches in diameter a pressure of only 10 lbs. would be required at the end of the winding, and that was less than the vacuum might be expected to be.

Mr. COWLISHAW endorsed what had been said by Mr. Favell about the gear, but considered that his remarks about compounding the winding-engine were premature, as the alteration had not been described to the members. They might expect great advantages from compounding, although the advantages already gained were greater than was expected.

Mr. JOHN HEATH said the Woodworth cut-off gear was working very efficiently at the Sneyd colliery. There was no doubt that they would use less steam than they had been using without it, and the work would be done more easily.

The PRESIDENT said they were very much indebted to Mr. Woodworth for his paper. He was satisfied that Mr. Woodworth's study had been to secure economy in working, and they were indebted to him for having brought his ideas before them. He moved a vote of thanks to Mr. Woodworth for his paper.

Mr. T. E. STOREY seconded the resolution, which was carried.

Mr. T. H. ARMSTRONG read the following paper on "The Rocket Oil-engine":—

THE ROCKET OIL-ENGINE.

By T. H. ARMSTRONG.

Oil-engines are useful motors, and possess features distinct from other forms of power, and many engineers have invented oil-engines. The majority of these engines which have come under the writer's observation are similar to each other in so far as the cycle of operations is concerned, the Otto cycle being almost universal, but the method of gasifying the oil and mixing it with air varies considerably, as does also the means of igniting the charge after it has been compressed; the system of regulating the supply of oil and obtaining uniform speed under varying loads has also afforded scope for the ingenuity of inventors, and we shall observe the points of difference as the construction and working of the Rocket oil-engine is being explained.

In this engine the oil for a day's supply is contained in the tank *A* (Figs. 1 and 2, Plate XIX.); thence it flows by gravity, when the cock is opened, to a reservoir *B*. From this reservoir, the oil is led by a pipe to the vaporizing-chamber, the quantity being regulated by means of a valve at *C* (Fig. 3, Plate XIX.). The end of this pipe being at a slightly higher level than the level of the oil at *B*, oil will not flow into the vaporizer, but when the piston travels on its first outward stroke, a vacuum is caused in the vaporizer, and oil and air rush in at the points *C* and *D* (Figs. 3, 4, and 5, Plate XIX.), the result being a spray of oil and air which is converted into vapour by the heat of the vaporizer. This vapour is mixed with more air at *F* (Fig. 1, Plate XIX.), and then passes into the combustion-chamber through the valve-port *G* (Fig. 7, Plate XIX.), this valve being raised at the proper moment by a lever operated by a cam on the side-shaft. After this valve closes, the piston on its return stroke compresses the charge after it has been admitted. The compressed charge is then fired by the ignition-tube *J* (Fig. 8, Plate XIX.), the result being the driving out of the piston on the third stroke, and its completing return stroke drives out the spent gases through the exhaust valve-port *K* (Fig. 7, Plate XIX.), this valve being also operated in a similar manner to the other. The momentum acquired by the fly-wheel keeps the piston moving between the explosions.

On starting the engine, the vaporizer is heated by a lamp (Fig. 6, Plate XIX.), an operation which can be performed in a few minutes, the oil and air is then turned on, the fly-wheel turned round twice, and the engine starts. The heating-lamp can then be extinguished, as the exhaust gases on their way out of the cylinder pass round the vaporizer, and give off sufficient heat to gasify the oil.

The ignition-tube is kept hot by a jet of gasified oil, fed by gravitation from a small reservoir (½ pint of petroleum being sufficient for a day's run). The governing of the engine is effected thus :—The explosive mixture on its way to the combustion-chamber passes through a port above *F* (Fig. 1, Plate XIX.). This port is nominally open. Attached to the end of the side shaft (which operates the two valves) there is a tripper and notch-piece. This notch-piece is tripped up at every alternate stroke of the piston, and if the speed exceeds what is desired, the end of the spindle is struck, this closes the door of the port above-mentioned, and prevents any oil-gas being passed into the cylinder. The speed of the engine can be adjusted as desired by regulating the tension of a spiral spring, which holds the notch-piece in position, and by the same means the speed can be varied from 50 to 500 revolutions per minute. The writer has never seen a more sensitive governor, as a variation in speed of 1½ per cent. brings it into operation. In addition to regulating the speed of the engine, it also effectually adjusts the consumption of oil according to the load.

As previously pointed out, the oil does not flow into the vaporizer, but is sucked into it by the out-stroke of the piston, and the governor closes the port on the suction-stroke, therefore no oil is vaporized when it so acts, economical results being obtained when the engine is required to work under varying loads, such as driving machinery in small workshops, hauling trucks in mines, etc.

The cylinder is water-jacketed, and the water can be arranged to circulate either by gravitation or otherwise. Provision is made for draining water out of the cylinder-jacket, so that in severe frosts there is no danger of cracking the cylinder.

The cleaning of the valves and vaporizer is a simple matter, as they are easy of access, and no joints require to be broken. The vaporizer being a separate casting can be detached from the engine by the unscrewing of a few bolts, and if the engine be required to work continuously night and day (as many of them are) a duplicate casting can be kept clean at bank, ready to be put on when the one in use has got dirty, and thus no time need be lost.

As there are no pumps about this engine, either for supplying air or oil, the maximum amount of power is available for effective work, and a high mechanical efficiency is obtained.

Many users of oil-engines find that their engines will only run with one particular kind of oil. This the writer attributes to the fact that the air-inlets are incapable of adjustment. In the Rocket oil-engine, the air-inlets may be regulated at will, and even if one brand of oil be used this arrangement of air-inlets will be found advantageous, as petroleum is affected by the temperature of the atmosphere, and in some mines this varies very much. Moreover, this arrangement enables the engine to be worked with equal success in the heat of India or the cold of Canada, as the proper quantity of air to form an explosive mixture can always be determined in a few minutes.

The method of igniting the charge in internal combustion-engines has received considerable attention at the hands of experts. The electric spark system possesses many features of advantage. If the engine be working in an exposed situation it is not affected by wind or draughts; the time when the circuit is closed can be very exactly determined, and thus the spark acts as a timing-valve. Where accumulators are kept constantly charged, electric ignition may possibly be economical, but in the majority of cases it is more costly than other systems, and requires more skill and care in its management. If the attendant attempts to start the engine too early, and a damp charge be admitted into the cylinder, the electrodes become wet, will not spark, and must be taken out and dried before the engine can be started.

Another form of ignition is by keeping the vaporizing-chamber itself at a great heat, and allowing the explosions themselves to maintain the temperature. This arrangement appears to be simple and convenient, but the writer has yet to be convinced that engines using this system of ignition will work efficiently under varying loads, or that they will run light for any length of time, as there must be considerable resistance to the piston, otherwise the required heat cannot be maintained. It seems probable that great care must be exercised in selecting oil to use with this system of ignition, otherwise there can be no guarantee that the explosion will always take place at the right moment. For, while it may be admitted that in 80 cases out of 100, petroleum-vapour will not explode until it is compressed to a certain degree, this cannot be called an inalterable law, as the writer has known petroleum to ignite when only slightly compressed, and once premature explosions are initiated the power will decline and result in a stoppage of the engine.

The indicator diagram is the unerring judge to which we must appeal, and the balance of evidence is in favour of a timing-valve, consequently the systems of ignition which admit of its use are to be recommended.

In the Rocket oil-engine, the port between the ignition-tube and the combustion-chamber is kept open, except during the period of compression, when the timing-valve (Fig. 8, Plate XIX.), operated by the side shaft, shuts off the light, until the compression is perfect and complete; the timing-valve can be kept closed a little longer when the engine is being started, to allow the crank to pass the dead-centre before ignition occurs, which is desirable.

Indicator diagrams taken from Rocket oil-engines are shown in Figs. 9, 10, 11, and 12 (Plate XIX.).

The writer was present at a trial made with a Rocket oil-engine of 10 brake horse-power driving a compound-wound dynamo. The load was purposely varied from 30 to 80 electric lamps of 16 candle-power, but there was no perceptible flicker in the lights, and the maximum fluctuation registered on the voltmeter was between $1\frac{3}{4}$ and 2 per cent. during three successive runs of 8 hours each.

The cost of working the Rocket oil-engines is regulated by the cost of petroleum: the quantity of oil used is rather under $\frac{3}{4}$ pint per brake horse-power per hour when fully loaded, and only slightly exceeds this quantity, when partly loaded, owing to the effective governor employed.

The exhaust gases from a Rocket oil-engine, are shown on analysis to consist by volume of :—

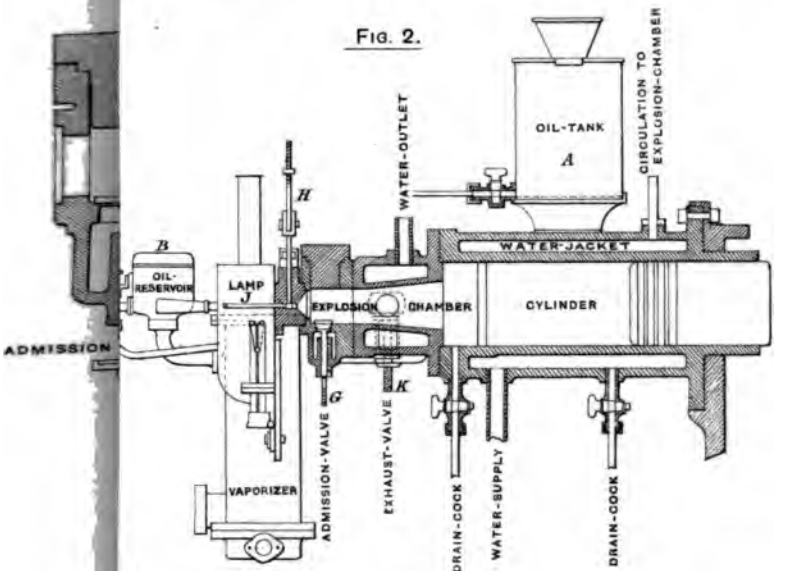
	Per Cent.
Nitrogen	84·1
Oxygen	7·2
Hydrogen	Nil
Heavy hydrocarbons	Nil
Marsh gas	Nil
Carbonic acid	8·5
Carbonic oxide	0·2
	100·0

It will be seen that the exhaust gases are harmless, that they will not burn or explode, and may be breathed with impunity.

But after all this has been said, when it becomes a question of introducing an oil-engine into the workings of a mine, where the ventilation is scanty and slow, then the exhaust gases are highly unpleasant and objectionable if they be allowed to accumulate, and render the adoption of an oil-engine impracticable, unless some exhaust-eliminator be applied.

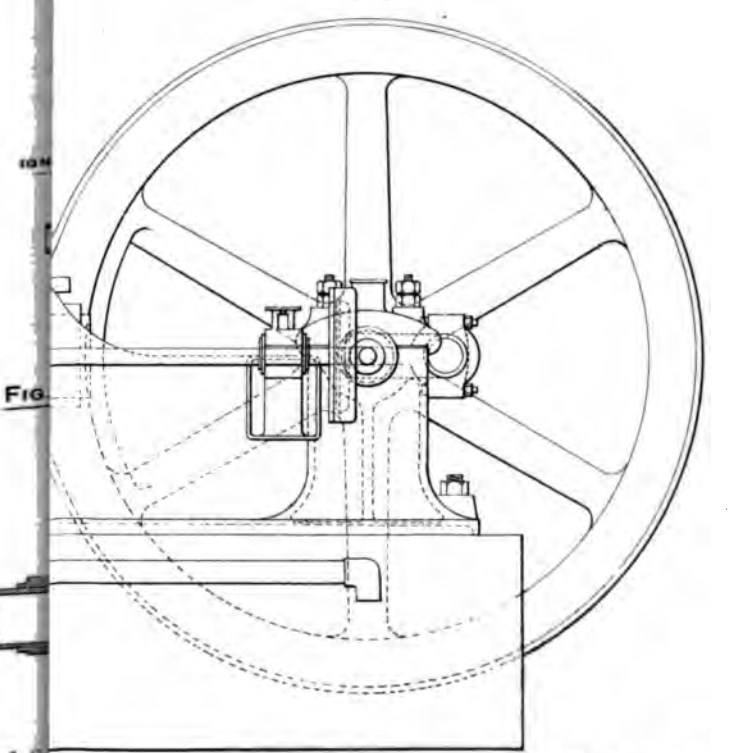
During the past six years many instances have been known to the writer, where the oil-engine has been passed by in favour of more costly

Fig. 2.



Longitudinal Section.

Fig. 1.



and troublesome means of obtaining power, such as steam, compressed air, wire ropes, electricity, etc., entirely owing to the difficulty of dealing with the exhaust-gases. The exhaust-eliminator entirely overcomes all objections.

The following table contains the specific gravities and flashing-points of oils used in oil-engines :—

Brand of Oil.	Specific Gravity at 60 degs. Fahr.	Flashing-Point. Degs. Fahr.
American, royal-daylight	0·790 ...	83
„ tea-rose	0·796 ...	83
„ water-white	0·780 ...	108
Russian, ordinary	0·835 ...	82
„ russolene	0·822 ...	86
British, Broxburn petroline	0·800 ...	100
„ „ No. 1	0·805 ...	110
„ „ lighthouse...	0·810 ...	160
„ Clippen's sunlight	0·805 ...	120

Previous to 1860, mineral oil was mostly obtained from Scotland by the distillation of shales. About that time, oil-wells were discovered in Pennsylvania, and the production of natural oil is now enormous, especially in the United States and South Russia. Oil-wells are now being exploited in Peru and other eastern countries.

Mr. W. BAILES enquired what quantity of oil would be required for a day's working, as it was an important matter to know what stock of oil would have to be taken to the engine.

Mr. T. H. ARMSTRONG said that for 7½ horse-power the consumption of oil when running at full power would be ¾ pint per brake horse-power per hour.

Mr. FAVELL said he was glad that the difficulty as to the smell from oil-engines had been overcome, as it removed one of the greatest objections to their use.

Mr. J. J. PREST thought that there was a still greater objection to oil-engines than the smell of the exhaust gases, and that was the danger of taking large quantities of petroleum into a mine. He had seen a Priestman oil-engine, and there was no difficulty with respect to the fumes. The place was enclosed, and the exhaust gases were conveyed directly into the return air-ways. The Rocket had some advantages over the ordinary Priestman oil-engine. The Priestman oil-engine, however, did its work satisfactorily, and pumped water without trouble.

Mr. B. WOODWORTH, in moving a vote of thanks to Mr. Armstrong for his paper, observed that, in the case of a Priestman oil-engine, used in a mine, the supply of oil never came into contact with the atmosphere after it left the stores on the surface. A small receiver of the Wells lamp type was used to convey the oil down the pit: the receiver was taken to the stores and the oil pumped into it. The vessel and its oil-contents was then taken into the mine, and connected by means of a flexible tube to the engine-reservoir; air was then forced by a hand-pump into the Wells type of receiver, until the oil was delivered into the engine-reservoir. As to the smell, if there was 1,000 cubic feet of air per minute to each horse-power of the engine the fumes would be rendered innocuous.

Mr. STOREY seconded the motion.

The PRESIDENT thought that the Rocket was an advance in oil-engines, and there were many places where such an engine might be used.

Mr. ARMSTRONG said he would not recommend the use of an oil-engine in dangerous mines. The oil used would not ignite even if lighted matches were dropped into it unless it was heated to a temperature of 80 to 100 degs. Fahr.

The motion was agreed to.

The meeting was then closed.

HESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

GENERAL MEETING,

HELD IN UNIVERSITY COLLEGE, NOTTINGHAM, DECEMBER 7TH, 1895.

MR. EMERSON BAINBRIDGE, M.P., PRESIDENT, IN THE CHAIR.

The following gentlemen were elected:—

MEMBERS—

Mr. WILLIAM BAXTER, Colliery Manager, Treeton Colliery, Rotherham.

Mr. GEORGE EDGAR SEYMOUR, Mechanical Draughtsman, 5, Rutland Villas, West Park, Chesterfield.

Mr. HERBERT SYDNEY SMITH, Colliery Manager, Littleworth, Woodville, Burton-upon-Trent.

Mr. ROBERT STEEL, Mechanical Draughtsman, 5, Rutland Villas, West Park, Chesterfield.

ASSOCIATES—

Mr. JAMES CHAMBERS, Deputy (holding First-class Certificate of Competency), Cavendish Villas, Portland Road, Hucknall Torkard, Nottinghamshire.

Mr. GEORGE WHARTON, Under Manager, Morton Colliery, Alfreton.

STUDENTS—

Mr. JAMES RAYNEY LEACH ALLOTT, Fitzwilliam Hemsworth Colliery, Kinsley House, Kinsley, Hemsworth, Wakefield.

Mr. BERNARD LUCAS BRODHURST, Glapwell Colliery, Chesterfield.

Mr. WILLIAM HENRY CARTER, Glapwell Colliery, Chesterfield.

Mr. WILLIAM LAW HALPIN, Blackwell Collieries, Alfreton.

Mr. GETHING HANCOCK, Bolsover Collieries, Chesterfield.

Mr. FRANK FELLOWS ROBERTS, Sutton Colliery, Sutton-in-Ashfield, Nottingham.

Mr. WILLIAM HAY, of Stanton Colliery, Burton-upon-Trent, read the following paper on "Fencing-gates for Winding-shafts":—

FENCING-GATES FOR WINDING-SHAFTS.

By WILLIAM HAY.

The writer is of opinion that fencing-gates at landings for simultaneous loading of two-decked cages should fulfil at least the three following conditions:—(1) They should effectually fence the pit-top landings when the cage is below ground; (2) when the gates are lifted by the cage, they should be balanced as nearly as possible, so as to minimize the blow on the caps of the winding ropes; and (3) the bottom landing should be safely fenced against men ascending on the top deck, and thus avoid any chance of their attempting to alight upon the bottom landing.

The writer believes that the gates described in this paper attain those conditions in a very simple manner.

Fig. 1 (Plate XX.) shows the gates open, *A* being the top gates, and *B* the bottom gates. The pair of gates on each side of each cage are connected by means of chains passing over pulleys. It will be observed that when the cage lifts the top gates *A*, the bottom gates *B* descend at the same time, below the bottom landing through the space *C* provided for the purpose (Figs. 1 and 3).

The lower gates *B* rest upon wooden blocks *D* attached to the timbers of the telescopic spring-boxes on which the cage-props are fixed; and these wooden blocks are arranged so as to stop the gates *B* before they pass out of the spaces *C* in the bottom platform.

The travel of the top gates *A* is $5\frac{3}{4}$ feet, and that of the gates *B* 3 feet. By this means the top gates *A* descend nearly 3 feet before the bottom gates *B* begin to lift. This enables the upper gate to be made much lighter than if it lifted the lower gate as soon as the cage begins to descend. The slack chain, due to the difference in the travel of the upper and lower gates, generally lies on the bottom platform, as shown in Fig. 1.

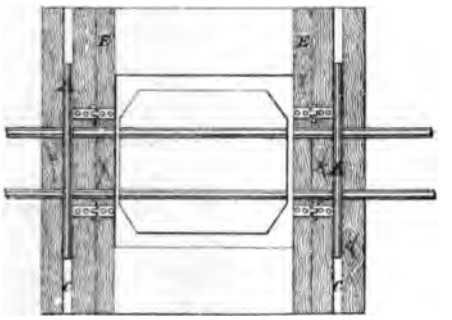
Fig. 2 shows the gates closed, and it will be noticed that the gates are kept in position when travelling by suitable iron guide-rods.

The tubs are open-ended, and lip-pieces (*E*, Figs. 1 and 3) are provided, which can be raised in the event of coal projecting beyond the ends of the cage.

The gates are made of flat iron laths, $1\frac{1}{2}$ and 2 inches wide and $\frac{1}{4}$ inch thick.

To illustrate Mr. W. Hay's Paper on "Fencing Gates for Winding Shafts."

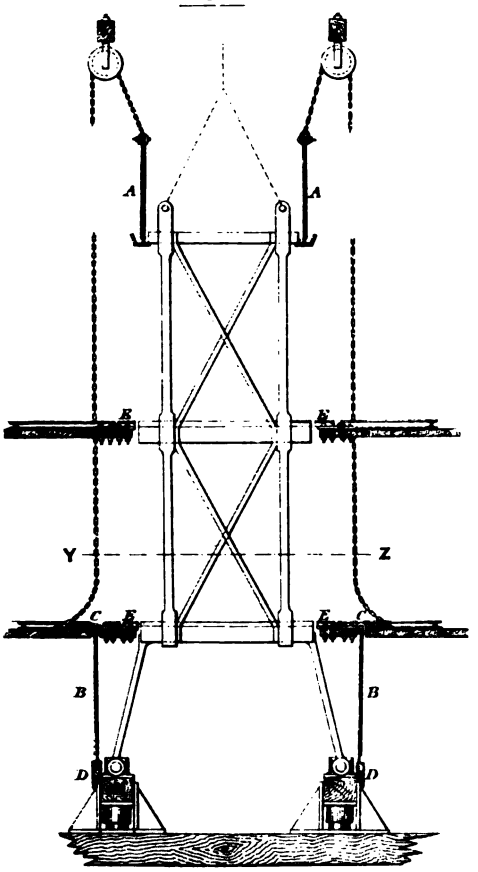
FIG. 3.



PLAN THROUGH LINE Y Z
OF FIG. 1.

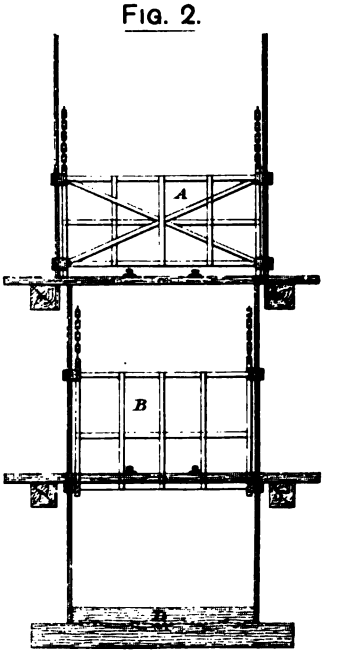
FIG. 1.

Scale 6 Feet to 1 Inch.



SIDE ELEVATION SHEWING
THE GATES OPEN.

FIG. 2.



ELEVATION SHEWING THE
GATES CLOSED.

Mr. A. H. STOKES (Derby) said that the question of fencing shafts was a very important one, especially with a double-decked cage. When men were being lowered or raised upon both decks, the points to be made clear was how the banksman on either deck should communicate with the other banksman, and which of them ought to give the signal to the engineman. A case illustrating the danger which might arise from dual control occurred at a large colliery some time ago. The cage consisted of two decks, and men were lowered from both of the bank-stages; the man in charge of the upper stage was the banksman in charge of the cage, and gave the signal to the engineman: the man on the lower stage had the duty of seeing so many men get upon the lower deck of the cage. There was an agreed signal to be given by word of mouth by the man on the lower stage to the banksman on the upper stage. One morning, when the men were going to work, the banksman on the upper stage got his full complement of men on the cage, and the man on the lower stage had nearly got his full number when he saw a man coming along the bank towards the cage, and called to him to come along quickly. However, the banksman above thought that he gave the agreed verbal signal, and thereupon signalled the engineman. The cage was started accordingly, with the result that the unfortunate late-comer was struck by the bar of the descending cage, and thrown from the top to the bottom of the shaft, a distance of about 1,200 feet. If managers had a double-decked cage, and both decks were used by the workmen, then the banksman in charge must have some arrangement at his command by which he could effectively close both decks before he gave the signal to the engineman. There were some banking arrangements in operation which partly carried out this requirement. He had not seen Mr. Hay's fencing-gates, and would like to ask him how he would ensure safety in such a case as he described. Some fences consisted of a series of iron rods or bars; the top bar of the cage would lift Nos. 1, 2, and 3 rods on the lower deck, and passing to the upper deck, would raise Nos. 4, 5, and 6 rods, carrying all the bars up together, but that would not meet such a difficulty as the one he had named. Perhaps Mr. Hay could suggest an arrangement which would secure the simultaneous fencing of both stages, and the complete control of the loading and signalling by one banksman when lowering and raising workmen.

Mr. C. J. OLIVER (Chesterfield) said there appeared to be one serious objection to the fence which Mr. Hay had described, that no fence was provided should the cage be lifted higher than usual. For instance, when the bottom deck of the cage was set at the top landing, the bottom stage would be left entirely unfenced and a tub might easily be accidentally pushed into the shaft.

Mr. STOKES said there was an arrangement in use which, although not perfect, might form the basis of a satisfactory fence: the banksman, by pulling a handle, simultaneously fenced both decks of the cage, so that no man could get on after the handle was turned down, and this was done by the banksman in charge before giving the signal to the engineman.

Mr. GEORGE FOWLER (Nottingham) said that he had an arrangement (with a three-decked cage) of three or four bars sliding on rods or wire-ropes; the bars were lifted one by one as the cage rose, and as it descended fell back into place and formed an efficient fence. At Cinder Hill collieries, in addition to the loose bars, there were three sliding-bars worked by the banksman on the pit top; there was little chance of men or tubs falling into the pit, owing to the double protection afforded by the loose bars worked by the cage and the additional arrangement worked by the banksman.

Mr. HAY, in replying to the discussion, said that the weight of the top gate was 50 lbs. and of the bottom gate 38 lbs., the difference between the weights being just sufficient to keep them at rest until moved by the ascending cage. The gates had been in use for 9 months, had never been known to stick in any way, and there never had been the slightest hitch in working them. The rods were periodically greased. A distinct signal was given by the top banksman to the lower banksman, and the latter gave an electric signal to the engineman. Before the introduction of these gates, he had a system of rods acting on different-sized guides, but a difficulty arose from the workmen being inclined to attempt to get off from the top deck on to the bottom landing. The lower deck of the cage was never drawn up to the level of the upper landing, consequently the suggested danger had never occurred. It would be seen from the illustrations (Plate XX.) that the gates guarding the bottom-landing did not complete their travel (and, consequently, leave the bottom-landing unfenced) until the top portion of the upper deck of the ascending cage was 2 feet above the floor of the upper-landing.

A vote of thanks was unanimously passed to Mr. Hay for his paper.

Mr. G. E. COKE (Chesterfield) read the following paper on a "Bori[redacted] below the Blackshale Coal-seam at Apperknowle, near Sheffield":—

BORING BELOW THE BLACKSHALE COAL-SEAM AT APPERKNOWLE, NEAR SHEFFIELD.

By G. E. COKE.

When the blackshale coal was becoming worked out in the Unstone valley, it became a pressing question for the Unstone Coal and Coke Company, and for the district generally, whether any other workable seams existed.

The Unstone coal-field is of limited extent, being thrown in on the north-eastern side of a continuation of the Brimington anticlinal, and forms a basin, the lowest point being at Unstone, the coal rising on all sides, following, to a great extent, the configuration of the surface.

As the depth of the blackshale coal-seam does not probably exceed 400 feet, the possibility of finding workable coal-seams above the blackshale, was not great. The furnace coal-seam has nearly died out in this direction, and the piper coal-seam was tried at the Unstone colliery and abandoned.

It became evident that no coal-seam above the blackshale could be profitably worked on a large scale, and the only hope therefore lay in the measures coming below it.

Early in 1893, a committee was formed with the object of raising a fund for proving the lower measures, and owing very much to the exertions and energy of Mr. F. L. Ward, manager of the Unstone collieries, and of Mr. Johnson, honorary secretary, and also to the encouragement and assistance afforded by the Unstone Coal and Coke Company, through the managing director, Mr. Emerson Bainbridge, a sufficient sum was raised by contributions from the colliery company, landowners, and others interested in the district, to justify a contract being entered into before the end of the year to bore from the bottom of the Apperknowle colliery, the sole survivor of the several collieries which had worked the blackshale coal-seam in the valley.

The boring machinery was placed at the bottom of the upcast shaft, which reaches the blackshale coal-seam at a depth of 390 feet from the surface. Boring was commenced on November 25th, 1893, and

continued with little interruption until June 30th, 1894, when the prospect of finding a workable coal-seam not being sufficient to justify any further expenditure, operations came to an end.

The diamond-boring machinery was of the ordinary pattern. Great advantage was found from the position of the machinery at the bottom of the shaft, as the rods were drawn from the surface enabling 390 feet to be lifted without unscrewing each length, a slow and tedious process. The time occupied in drawing this length of rods was three minutes, and for lowering into the hole again five minutes.

The hole was commenced with a diameter of 8 inches, and at the bottom it had been reduced to 5½ inches. A satisfactory feature of the boring was the large proportion of core obtained. Down to a depth of 750 feet only 12½ feet of core was lost, and this length was accounted for as follows :—

	Ft.	Ins.
Starting the borehole by hand before the diamond drill was used ...	5	0
Cut with the chisel after the diamond crown had been lost	1	6
Thickness bored through of coal which was broken up	4	4½
Core not accounted for	1	7½
Total	12	6

Some portion of the strata below the depth of 750 feet was of a very broken nature, and consequently could not be preserved satisfactorily, although very little, if any, was missing, each time the core-tube was drawn out of the hole.

Before boring operations were commenced, careful investigations and researches were made in order to trace the outcrop of the measures below the blackshale coal-seam. No satisfactory results were obtained however as both north and west of Apperknowle colliery the outcrops are very much disturbed by faults.

It was hoped that the Totley tunnel on the Dore and Chinley railway would have revealed something of importance, but here again faults prevailed, the dislocations of the strata being in some cases considerable.

On the south-western (or opposite side) of the Unstone valley Apperknowle colliery, one or two coal-seams were found some years ago not far below the blackshale coal-seam, but they do not appear to have a continuous formation in other parts of the valley.

The first thin seam of coal bored through gave off a large quantity of gas, so much that, for a time, operations had to be discontinued.

The next coal-seam, at a depth of 136 feet, was very dirty. This seam is generally known as the Mickley thick coal-seam, and at the o

crops to the north of the pit is about 4 feet in thickness, but in this thickness there are no less than six thin partings of dirt.

At 193½ feet, the Mickley thin coal-seam was reached, which, although of better quality than the coal above, is too thin to be of commercial value at the present time.

Very little importance can be attached to any of the strata passed through until 412½ feet in depth had been bored. Here 2½ inches of coal was proved, which at first was suspected to be the Kilburn, but, according to the depth below the blackshale coal-seam, the black bind with streaks of coal passed through at a depth of 498 feet would appear to be the right place to have found the Kilburn coal-seam. There is, however, nothing definite to establish this theory.

It has been suggested that the borehole has passed through a fault, but the position of the nearest fault in the blackshale coal-seam was such that if it continued at the same angle it would not pass under the borehole at a less depth than 2,250 feet.

The cores did not show any signs of faulty ground until a depth of 750 feet had been reached, at which point a large quantity of gas was given off and continued to come up the borehole until a depth of 900 feet had been reached, notwithstanding the great depth of water through which it had to pass.

At a depth of 750 feet, a grey sandstone was passed through, with thin beds of black stony bind and vertical veins of calcspar. These strata did not indicate any probability of coal being found for some distance below them. With this exception, and the great thickness of the bind a little below, which was very broken in places, there were no other signs of the ground being at all disturbed by faults, and the cores were very good.

The boring was carried to a depth of 1,000 feet with varying hopes, and then it became evident that the chances of finding a coal-seam that would benefit the district were almost *nil*. Under these circumstances, the subscribers decided to discontinue the operations, which were then definitely abandoned.

The value of this research depends to some extent on the correct interpretation of the results. Is this absence of coal below the blackshale merely local, or does it suggest that the lower mines found to the south die out and that other seams take their place and form the lower coal-series of South Yorkshire?

APPENDIX.—SECTION OF STRATA BORED THROUGH FROM THE BOTTOM OF THE APPERKNOWLE UPCAST SHAFT.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Rubbish	4	7	4	7
2	Bottom **COAL**, *Silkstone Coal-seam*	1	0	5	7
3	Fireclay	2	11	8	6
4	Fakey fireclay ...	6	0	14	6
5	Fakey fireclay, with ironstone balls, etc. ...	6	3	20	9
6	Blue bind ...	10	0	30	9
7	Blue bind, with **COAL** partings	13	5	44	2
8	**COAL**, strong blower of gas which lasted for 12 hours ...	0	3	44	5
9	Blue sandy shale, jointy	10	10	55	3
10	Blue bind ...	28	1	83	4
11	Hard grey sandstone	1	4	84	8
12	Blue sandy shale, very much broken	17	3	101	11
13	Fakey sandstone	0	10	102	9
14	Grey sandstone ...	5	0	107	9
15	Blue sandy shale	3	0	110	9
16	Grey sandstone ...	4	0	114	9
17	Blue sandy shale	5	0	119	9
18	Blue bind ...	8	0	127	9
19	Hard grey sandstone	1	3	129	0
20	Grey sandstone, very much broken	5	8	134	8
21	**COAL**	1	4	136	0
22	Blue shale, with thin **COAL** partings ...	4	10	140	10
23	Fakey sandstone	3	6	144	4
24	Blue bind ...	3	9	148	1
25	Blue bind, with ironstone balls	2	7	150	8
26	Blue bind ...	5	0	155	8
27	Black bind ...	1	3	156	11
28	Dark blue bind, with ironstone veins	9	10	166	9
29	Ironstone ...	0	4	167	1
30	Dark blue bind ...	3	0	170	1
31	Ironstone ...	0	4	170	5
32	Dark blue bind ...	2	3	172	8
33	Black shale, inferior **CANNEL COAL** ...	1	6	174	2
34	Dark blue bind ...	0	10	175	0
35	Ironstone ...	0	4	175	4
36	Blue bind ...	6	1	181	5
37	Ironstone ...	0	5	181	10
38	Blue bind ...	10	4	192	2
39	Black shale ...	0	3	192	5
40	**COAL**	1	1½	193	6½
41	Blue bind ...	3	1½	196	8
42	Blue bind, with ironstone balls and veins of black shale ...	10	0	206	8
43	Blue shale ...	3	6	210	2
44	Grey sandstone ...	8	4	218	6
45	Blue bind ...	13	0	231	6
46	Blue bind, with ironstone balls	6	0	237	6
47	Black shale ...	1	3	238	9
48	Blue bind ...	3	0	241	9
49	Black bind ...	0	8	242	5
50	Blue bind ...	1	0	243	5
51	Black bind ...	0	4	243	9
52	Dark blue bind, strong	8	11	252	8
53	Black shale, with **COAL** partings	1	4	254	0
54	Dark blue shale	0	9	254	9
55	Blue bind, with ironstone balls	4	6	259	3
56	Grey sandstone ...	2	0	261	3
57	Blue bind, with ironstone balls	9	0	270	3
58	Blue bind ...	6	0	276	3
59	Dark blue bind ...	27	11	304	2
60	Grey sandstone ...	0	10	305	0
61	Fakey sandstone, with ironstone partings ...	2	1	307	1
62	Blue sandy shale	10	8	317	9
63	Blue bind ...	0	10	318	7
64	Blue bind, with ironstone balls	1	8	320	3
65	Black shale ...	1	6	321	9
66	Blue bind, with ironstone balls	4	0	325	9
67	Fakey sandstone	7	4	333	1
68	Blue bind ...	1	8	334	9
69	Fakey sandstone	0	7	335	4
70	Blue sandy shale	5	8	341	0
71	Blue sandy shale, with rock-partings	4	6	345	6
72	Grey sandstone ...	2	4	347	10
73	Blue sandy shale, with rock-partings	3	2	351	0
74	Blue bind ...	6	4	357	4
75	Black shale ...	3	0	360	4
76	Blue bind ...	3	1	363	5
77	Grey sandstone ...	0	3	363	8
78	Blue sandy shale	3	9	367	5
79	Grey sandstone ...	1	9	369	2
80	Blue sandy shale	3	0	372	2

of	Thickness of Strata. Ft.	In	Depth from Surface. Ft.	In.
shale,				
ıstone				
...	3	9	375	11
...	8	0	393	11
...	1	0	384	11
...	1	6	386	5
stone,				
oroken	4	5	390	10
...	3	0	393	10
one ...	0	10	394	8
...	14	0	408	8
with				
part-				
...	2	9	411	5
...	1	0	412	5
..	0	2½	412	7½
...	1	3½	413	11
with				
ngs ...	1	6	415	5
one ...	2	8	418	1
ind ...	4	3	422	4
shale	1	5	423	9
...	1	0	424	9
with				
part-				
...	6	10	431	7
one ...	1	8	433	3
stone	6	6	439	9
one...	8	0	447	9
...	1	3	449	0
...	2	6	451	6
stone	3	6	455	0
stoney				
...	24	2	479	2
...	17	2	496	4
, with				
COAL	1	8	498	0
fossils	1	6	499	6
with				
balls	12	3	511	9
ind ...	1	4	513	1
...	0	8	513	9
ind ...	5	10	519	7
with				
s of				
ıstone	0	6	520	1
stone	7	8	527	9
bind	21	11	549	8
...	2	3	551	11
with				
nstone	4	6	556	5
...	2	0	558	5
h thin				
black				
...	1	7	560	0
, with				
balls	1	8	561	8
...	1	10	563	6
...	0	2½	563	8½
...	0	1	563	9½
r ...	0	1½	563	11

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
125	Clunch	1	7	565	6
126	Dark blue stoney bind, with ironstone balls ...	6	0	571	6
127	Dark blue stoney bind	6	2	577	8
128	Fakey sandstone and black partings	2	6	580	2
129	Fakey sandstone	6	2	586	4
130	Dark blue bind	17	8	604	0
131	Dark blue bind, with ironstone partings .	4	0	608	0
132	Dark blue bind, very slatey ..	23	3	631	3
133	Light blue bind...	1	4	632	7
134	Grey sandstone ..	2	3	634	10
135	Dark grey sandstone, very close grained ...	11	2	646	0
136	Fakey sandstone	6	0	652	0
137	Blue stoney bind	3	2	655	2
138	Blue bind ...	9	6	664	8
139	Fakey sandstone	1	6	666	2
140	Blue stoney bind	18	6	684	8
141	Blue bind .	7	9	692	5
142	Fakey sandstone	1	0	693	5
143	Blue stoney bind	4	0	697	5
144	Fakey sandstone	1	1	698	6
145	Blue stoney bind	6	0	704	6
146	Grey sandstone ..	8	2	712	8
147	Fakey sandstone	4	10	717	6
148	Blue stoney bind	1	7	719	1
149	Fakey sandstone	7	0	726	1
150	Blue stoney bind	4	10	730	11
151	Fakey sandstone	1	4	732	3
152	Blue stoney bind	5	0	737	3
153	Blue bind ...	10	6	747	9
154	Fakey sandstone	1	10	749	7
155	Grey sandstone, with thin beds of black sandstone and vertical veins of spar	11	4	760	11
156	Fakey sandstone	2	6	763	5
157	Blue stoney bind	7	9	771	2
158	Blue bind, very much broken in places	83	9	854	11
159	Blue bind, with partings of ironstone	1	0	855	11
160	Dark blue bind ...	6	4	862	3
161	Black bind and one parting of ironstone ...	38	10	901	1
162	Very dark blue bind	6	7	907	8
163	Strong clunch ...	4	8	912	4

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
164	Strong grey rock	4	0	916	4
165	Blue bind ...	4	0	920	4
166	Dark blue bind, with ironstone partings ...	2	3	922	7
167	Blue bind ...	7	6	930	1
168	Dark blue bind ...	19	2	949	3
169	Fakey sandstone and one thin parting of COAL	26	4	975	7
170	Dark blue stoney bind	6	0	981	7
171	Blue bind ...	10	0	991	7
172	Dark blue bind ...	8	0	999	7

The PRESIDENT remarked that the circumstances relating to the boring were unique, inasmuch as the cost of the undertaking was subscribed by the lessors and the lessees of the coal-field, in conjunction with the tradesmen and the working-men of the district, who showed a great deal of public spirit in their attempt to prove by means of the borehole whether there was coal in the district existing beneath the blackshale coal-seam. The borehole was stopped, owing to the hopelessness of finding any workable seam below that seam. The Mickley coal-seam was evidently only of local occurrence, and the endeavour to find the Kilburn coal-seam had proved a failure. A favourable result of the boring would have been of the very greatest importance to the collieries now working the blackshale coal-seam, and if the existence of a lower seam had been proved it would have brought fresh life and hope to a very large and important district close to the manufacturing centre of Sheffield.

Mr. J. H. W. LAVERICK (Riddings) asked whether Mr. Coke or any member could give information as to the nearest point to the Apperknowle borehole, where the Kilburn coal-seam had been proved, its thickness, and whether it was workable? The Kilburn coal-seam in the neighbourhood of Riddings was there regarded as being the only seam below the blackshale of any value. It gradually became thinner in a northerly direction until it diminished to 1 foot 10½ inches in thickness, when its further working was discontinued, owing to the high costs.

Mr. M. H. MILLS (Mansfield) said that the Kilburn coal-seam at Kilburn was no doubt a very valuable coal, but northward it appeared to thin out, and the measures thickened between the blackshale and the Kilburn coal-seams. He believed that the Kilburn coal-seam had been proved at Clay Cross collieries, but it was of no value, being of the same thickness as Mr. Laverick had mentioned as existing at Riddings.

He had hoped, although the Kilburn coal at Apperknowle might be of no value, that they would have found below the blackshale, the Mickley or Naughton coal-seam, which might have thickened out and become of value.

Mr. A. H. STOKES believed that the Kilburn coal-seam had been worked, and was of a fair thickness at the Clay Cross collieries. It was also found near to the Wingfield churchyard. It was strange that the Kilburn coal-seam had not been found in the Apperknowle boring. He had known a borehole to pass through a coal-seam 4½ feet thick without being recognized, and the seam which was thought to be non-existent was now being worked. He did not intimate that such a thing occurred in this case.

The PRESIDENT said that the borehole was intended to ascertain the existence of the Alton, the Mickley, and the Yorkshire Whinmoor coal-seams, all of which lie below the blackshale; but the borehole did not find one workable seam.

The SECRETARY (Mr. W. F. Howard, Chesterfield) said that the Alton colliery (now closed) was situated westward of Stretton station. The Alton seam was worked successfully; it was more than 4 feet thick, and made very good coke. When the colliery was nearly exhausted, a deeper shaft was sunk, but the sinking proved abortive. It was his impression that it had been sunk in faulted ground.

Mr. STOKES said that at Wollaton, a shaft was sunk to find the Kilburn coal-seam, and found nothing; but that seam was found a short distance away, and was at present being worked towards the Wollaton shaft.

Mr. H. LEWIS said Mr. Stokes had alluded to the possibility of a boring going through a seam of coal and not finding it. He happened twenty-five years ago to be in charge of a boring, and that was his experience.

The PRESIDENT said that the improved diamond-boring machinery, by which the borehole at Apperknowle had been put down, made the position, section, and existence or non-existence of coal-seams much more certain than was formerly the case.

Mr. COKE, in reply to the discussion, remarked that there was some confusion as to the relative horizons of the Naughton and the Alton coal-seams. He believed that the Naughton coal-seam was found about 350 feet below the Kilburn, and the Alton seam about 150 feet deeper. The

Naughton coal-seam was of inferior quality, and mixed with dirt-bands. The Alton coal-seam had been worked near Clay Cross, and proved in the neighbourhood of Nottingham; it comprised 3 feet 4 inches of good coal. He was connected with a boring now being carried on, and he could say with great confidence that even a thin seam of coal ought not to be missed if ordinary care was used. The revolutions of the crown increased when coal was touched; the machinery should then be stopped, and the core drawn to prevent the coal from being pounded by the strata already in the core-tube. The crown should then be again lowered on to the coal, the position of the cross-head marked with chalk, and the seam bored through. The machine would begin to thump when the solid strata were reached; the cross-head would again be marked, and the thickness of the seam be accurately measured. From 1½ to 3 or 4 feet would then be bored, the core drawn, and the coal should be found in the core-tube above the solid clunch, or whatever lay below it.

Mr. H. Lewis asked if, in a very soft coal, it was possible to get a core? If, when coal was reached, the machine revolved more rapidly or ran away, was it not possible that the man in charge might not recognize the fact and go through the coal without knowing?

Mr. Coke said that the increased speed of the machine could not fail to be noticed.

Mr. H. Lewis—But supposing the man was not watching the machine it might go through a 3 feet seam in three minutes.

Mr. Coke said it would take fifteen minutes, and remarked that another question arose as to whether the Apperknowle boring was in a rock-fault or whether it proved the dying out of the Coal-measures, which came in again on the northern side of Sheffield.

Mr. John Jackson (Chesterfield) wrote, enclosing the following section of the sinking and boring on the Stubben Edge estate to the gannister coal-seam. A new colliery was commenced in 1874, but was not completed: one shaft was sunk to within about 120 feet of the coal-seam, and the other to within 180 feet. In the former, a borehole was put down which passed, at a depth of 590 feet from the surface, through 9 inches of gannister rock, 5 feet 7 inches of coal, and 2 feet of fireclay. The old colliery was worked to the outcrop, and the rock, coal, and clay were of excellent quality. The measures rear up very quickly to the gritstone, but in the new sinking the inclination of the seam was about 1 in 15, so he (Mr. Jackson) was informed by men who worked in the shaft.

SECTION OF STRATA SUNK AND BORED THROUGH AT ALTON COLLIERY IN 1875.

No. of Strata.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
	Sinking.				
1	Sandstone ...	6	6	6	6
2	Light blue shale bind	9	0	15	6
3	Sandstone rock ...	37	0	52	6
4	Light blue bind...	6	0	58	6
5	Hard cank bed ...	3	0	61	6
6	Light blue bind...	8	0	69	6
7	Cank bed ...	2	6	72	0
8	Light blue bind...	9	6	81	6
9	Cank bed ...	1	6	83	0
10	Light blue bind...	67	0	150	0
11	Light blue bind, much stronger and in thicker beds	126	0	276	0
12	Blackshale bind	54	0	330	0
13	Black cank, very hard	0	9	330	9
14	Sandstone ...	0	5	331	2
15	Fireclay, the upper half of a light colour, and the bottom part is light blue ...	5	0	336	2
16	Brown rock ...	2	0	338	2
17	Dark bind ...	29	0	367	2
18	Brown rock, hard	2	0	369	2
19	COAL smut ...	0	5	369	7
20	Light rock, with black markings	2	3	371	10
21	White rock ...	4	0	375	10
22	Dark blue bind ...	30	0	405	10
23	Blackshale bind, with ironstone balls	8	0	413	10
24	COAL smut ...	0	7	414	5
25	Gannister rock ...	1	6	415	11
26	Fireclay	5	3	421	2
27	Strong brown rock	2	6	423	8
28	COAL smut ...	0	1	423	9
29	Black clunch ...	0	10	424	7
30	White rock, very hard	12	6	437	1
31	Blue bind ...	4	0	441	1
32	Light brown rock	14	6	455	7
33	Light rock and blue bind, mixed in thick and thin beds	13	6	469	1
34	Soft blue bind and rock, mixed in beds	6	0	475	1
	Boring.				
35	Strong dark bind	21	0	496	1
36	White rock, very hard	12	6	508	7
37	Dark blue bind, strong	55	6	564	1
38	Blackshale bind, with ironstone balls near bottom	25	0	589	1
39	Rock	0	9	589	10
40	COAL, *Gannister Coal-seam* ...	5	7	595	5
41	White fireclay ...	2	0	597	5

The PRESIDENT remarked that Mr. Coke could hardly expect much discussion, since the neighbourhood was unknown to many of the members. The borehole lay to the westward of a large area of coal worked by the Staveley Coal and Iron Company, and when that company had exhausted their present coal-field no doubt they would make borings within a few miles of Unstone, and prove at another point whether there were lower workable seams. They were very much indebted to Mr. Coke for reading the paper, which, many years hence, would have more value than it had to-day. They had to be prepared, as mining engineers and colliery proprietors, for the exhaustion of the coal-seams in that district and in the Midland counties. Countries like the United States of America were now working coal under the same conditions as those that existed in England forty years ago, viz., thick seams won by drifts from the surface and cheaply worked. Within thirty years, English collieries would largely depend on seams proved by boreholes similar to that described, and he hoped that in other districts more success might attend such efforts than had been the case at Unstone.

A vote of thanks was accorded to Mr. Coke for his paper.

DISCUSSION UPON THE "REPORT OF THE PROCEEDINGS OF THE EXPLOSIVES COMMITTEE."*

Mr. STOKES expressed the opinion that foreign experiments had been of more practical value than those made in England, because the former were conducted under conditions which more nearly approached what would occur in a mine. There had recently been a most unfortunate and disastrous example of the effect of blasting-powder in a dry and dusty mine in this district, and it showed the different results of experiments on a small scale and on a natural scale. He referred to the experiments made by the Chesterfield and Midland Counties Institution of Engineers some years ago that were made on a small scale and in these trials the low main dust of Blackwell colliery was not fired, and to the disastrous experiment on a natural scale within the last month in the workings of that colliery.

The Explosives Committee of the North of England Institute of Mining and Mechanical Engineers had made a large number of experiments and published some of their results, but the adverse criticism which had been passed upon the mode of conducting the experiments and the deductions arrived at, rendered it advisable to wait for further information before acting upon that Committee's *Report*. One inference to be drawn from the *Report* was that 6 inches was as good as a much greater length of stemming; but the Committee stemmed with damp puddled clay in a cannon: that was very different from the stemming used in a coal-mine. The cannon, it must be presumed, would have a smooth bore, the damp puddled-clay stemming would act like a lubricator, and the stemming would easily be driven out; a drill-hole in a coal-mine would not always be circular, but frequently would have irregular angular projections which would serve to hold the stemming tight. One member (Mr. W. C. Blackett) had tested the power to force stemming, and stated that 6 inches of damp puddled-clay stemming took 56 lbs. to move it, and that 6 inches of damp seggar stemming took 1,232 lbs. to force it out.† He thought that the Committee would have benefited by the experiments being open to all members of The Federated Institution of Mining Engineers. Not only would they thus have been relieved of some adverse criticism, but many more points would have been suggested by visitors to the works for con-

* *Trans. Fed. Inst.*, vol. viii., pages 227 and 593; vol. ix., pages 115, 206, and 274; and vol. x., pages 38 and 197.

† *Trans. Fed. Inst.*, vol. viii., page 597.

sideration. He thought that a representative of the makers of each explosive in process of being tested should have been present, who should have been authorized to provide his own sample; as it had been found that owing to various causes, the high explosives in some cases deteriorated either through keeping or owing to their constituent parts not being thoroughly incorporated. It was probably owing to this deterioration that occasionally the whole of a cartridge did not explode. It was also desirable that a representative of the makers of the explosive on trial should be present, so as to ensure the proper detonator being used. The objection that visitors would have been too numerous or troublesome might have been met by the issue of tickets. As a member of the Committee appointed by the Chesterfield and Midland Counties Institution of Engineers to carry out their experiments on coal-dust, he could say that they received most valuable suggestions from members outside the Committee.

With respect to the use of blasting-powder, he thought that recent experience had clearly shown that blasting-powder was the most dangerous of all explosives used in a coal-mine. In a dry and dusty mine, blasting-powder appeared to be able to ignite the dust whether gas was present or absent. It was no doubt open to question what place in a mine should come under the designation "dry and dusty." It appeared to him that the use of blasting-powder ought to be prohibited in all main roadways of a mine where there was any chance of dust accumulating.

Mr. J. H. W. Laverick (Riddings) said he was pleased to hear Mr. Stokes draw the line of prohibition of the use of gunpowder at places which contained accumulations of dust, as such accumulations did not exist at the working-face where gunpowder was very largely used. If at the present time the use of gunpowder at the coal-face were prohibited, he believed that it would result in the closing of many existing mines. It was sincerely to be hoped that an efficient substitute for gunpowder would soon be invented: it should be flameless, economical, not too shattering in its effects, suitable for coal, rock, or bind, and exploded in such a way and by such means as would not introduce new elements of danger into mines.

Mr. Stokes remarked that there were colliery managers who used safety-explosives, and ignited them with an ordinary fuze. At one colliery, where safety-lamps were in use, and where only an official was allowed to fire a shot, and then only with a wire heated through a hole in the glass of the official's locked safety-lamp, the high explosive was fired

by an ordinary fuze ignited by the heated wire. It was well known that an ordinary fuze would ignite gas at a distance of 8 or 10 inches away from an ordinary gas-jet, the fuze being held in a direct line with the jet. In the case he had mentioned, the manager was a severe disciplinarian, and yet allowed ordinary fuze to be used for the ignition of a safety-explosive when gas was present, and when the official lit the fuze he lit the gas also, and was burnt.

Mr. GEORGE FOWLER (Nottingham) remarked that as a mine owner and colliery manager in Warwickshire, he had had to contend more with the difficulties of mind than of matter. In that county, as also in Nottinghamshire, he had been doing his very best to absolutely discard the use of powder in the mines under his charge. He had made a number of experiments with ardeer powder, bellite, carbonite, and roburite, and found bellite to be the most efficient explosive. The great difficulty, however, was to induce the workmen to agree to the disuse of blasting-powder. With this view he chose a fine day, and in an open space prepared a heap of coal-dust, and announced to the workmen that he wished to show them the effect of blasting-powder in coal-dust, as compared with safety-explosives. A blasting-powder cartridge was fired, and the dust burst into a mass of flame. He pointed out to the workmen that if such an ignition had occurred in the mine they would have all become cinders. Into a similar heap of dust, charges of ardeer powder, bellite, and roburite were then disharged without the slightest sign of firing the dust, which was merely blown away in black clouds. In no case could they succeed in igniting coal-dust with a safety-explosive. Within three weeks he was met by his workmen, and told that they declined to use bellite.

Mr. Stokes had referred to another point—the use of an ordinary fuze when using safety-explosives. He admitted that fuze was not absolutely safe, but what was he to do? He could not get the workmen to use magnetic detonators and safety-explosives, together, at present. It was better, he contended, to fire a safety-explosive with fuze than not to use a high explosive.

The PRESIDENT, with regard to the Blackwell explosion, said that the Blackwell company had not depended on the experiments made on a small scale in Chesterfield with coal-dust; they had been conducting experiments of their own every day for twenty years past, and over 20,000 shots had been fired in the various roadways, under exactly the same conditions as when the accident happened the other day, except that in the accident more blasting-powder was probably used than ought to have been,

and hence the flame was more pronounced. Yet, in all these experiments, going on constantly, there had only been one accident to show that dust in that mine had a greater degree of danger than shown by the experiments at Chesterfield. They might make experiments for ever, and might never exactly comply with the conditions existing in a mine. There were two kinds of coal-dust—the coal-dust which falls and the coal-dust which rises. It was the latter—the impalpable dust which is deposited from the coal-tubs which was the source of danger. At the coal-face, as a rule, there was very little of very fine dust, and the danger of an explosion at the face from dust was very small. Mr. Stokes made a slight error when he stated that the danger was equally present whether the dust was mixed with gas or whether it was not. Whilst it was possible to have explosions with dust alone, a very small percentage of gas present emphasized the effects of an explosion to a very great degree. They had heard a great deal about the use and the fallibility of the so-called flameless explosives. He would suggest that some member should contribute a paper on "Flames caused by Flameless Explosives," for he did not think any of them could say that they had yet found an absolutely flameless explosive, although some were nearly so. He went out to Germany and witnessed severe tests of carbonite and roburite, and no flame was produced. In the cases where flame had been produced there had perhaps been want of uniformity in the composition of the explosive. If flame had been seen in a single experiment, it proved that there was a risk of danger always existent. There was no doubt, however, that experiments and practice proved that certain explosives possessed a degree of safety which blasting-powder did not.

Mr. STOKES said the President had misunderstood his meaning. He was of opinion that in a dry and dusty mine, blasting-powder appeared to be able to ignite the dust, whether gas was present or absent.

Mr. J. L. HEDLEY (H.M. Inspector of Mines, Newcastle-upon-Tyne) wrote that the Explosives Committee had invited criticism, whether favourable or otherwise, and regretted that there had been so little. The members were pleased that Mr. Stokes had taken such interest in the matter, and had expressed his opinion. It was necessary, in order to render the *Report* of value, that the conclusions should be thoroughly discussed. Many of the points touched upon by Mr. Stokes had, however, already been raised in discussion elsewhere, and replies given to them, more especially those relating to stemming, and he would find in the *Report* full explanations of the kind of stemming, and why it was used.*

* Pages 9, 10, 31 and 32.

It would be interesting to know in what respects the foreign experiments had been of more practical value than those made in England, as the latter were carried out under somewhat similar conditions to those existing in a mine, so far as stemming was concerned.

It should not be forgotten that the experiments of the Committee were carried out, not with the view of testing the strength of the cannon, but of ascertaining whether safety-explosives would ignite gas or dust in the case of a blown-out shot.

Mr. Stokes, in alluding to the Blackwell colliery explosion, apparently condemned experiments made on a small scale, and instanced the experiments made by the Chesterfield and Midland Counties Institution of Engineers with the low main coal-dust from that colliery, where no ignition was obtained. The inference to be drawn from his remarks was, that although the Committee succeeded in producing ignitions of gas or coal-dust under certain conditions in their apparatus, it did not follow that they could do so in a mine. Perhaps not; but they had proved that the explosives tested were not safe under all the conditions which may, and do, occur in mines.

Mr. W. C. Blackett's experiments with regard to stemming were made under very different conditions, and were in no way analogous to those existing in the case of a shot. In the latter, we have force resulting from detonation, whereas in the former he simply exerted a steady pressure by means of a piston, until the clay began to ooze out from the bottom of the cylinder.

The question of the introduction of strangers to the proceedings of the Committee was fully discussed by the Council, and it was unanimously decided that it would be undesirable to permit it, for many self-evident reasons. To have allowed manufacturers to attend and to provide their own explosives would have defeated the very object for which the Committee was formed, namely, to make independent tests; and with this end in view, the explosives were procured from collieries where they were in actual use. If they had in any way deteriorated, before use at Hebburn, and, consequently, were not in the same condition as when manufactured, they would be equally unfit to use in the mine; it was therefore necessary that attention should be drawn to this fact, which showed the necessity of testing explosives in the condition in which they were sometimes used.

Mr. Stokes had evidently overlooked the fact that the experiments made by the Chesterfield and Midland Counties Institution of Engineers and those made at Hebburn were of a totally different character, inasmuch

as the latter affected a large manufacturing industry of newly-invented explosives; and to have published an unfinished series of experiments with any one explosive might have done serious injury to the makers of the others, and probably have led to false conclusions being formed.

He (Mr. Hedley) agreed with Mr. Stokes that the use of blasting-powder should be prohibited in the main roadways of a mine, where there was any chance of dust accumulating, but he would go further, and advocate its abandonment in all parts of a mine, when dry and dusty.

DISCUSSION UPON MR. H. R. HEWITT'S PAPER ON "AN UNDERGROUND ENDLESS-ROPE AT THE MOSTON COLLIERY, MANCHESTER.*

Mr. H. R. HEWITT regretted that he could not give any additional information as to the working of the rope beyond the statements that he had already made. The costs of the haulage with the single-rope per ton were four times the cost that they are now. He had recently been making enquiries as to the relative costs of single-rope and endless-rope traction at several collieries where the gradients were heavy, as Mr. Spencer and others suggested that where a single-rope would work it was not desirable to change the system to endless-rope haulage. He had chosen two collieries for comparison, one in Leicestershire where the single-rope is being used, and the other in Warwickshire using the endless-rope. Both planes dipped 1 in 3 to 1 in 4, and each was about 3,600 feet long, with two intermediate landings, the output in each case being about 800 tons per day. The cost per ton in the former case was 5d., and in the latter case a little under 1d. The cost of ropes in the endless-rope system mentioned did not exceed 0·37d. per ton, and it was scarcely possible to reduce this by using another system. This item of cost should really be much less with endless-rope haulage than with any other, because of the reduced speed at which it runs. Although a double length of rope was requisite for the endless-rope, the difference in the speed would, he believed, always compensate for the extra length by the saving of wear and tear.

Some of the advantages of endless-rope haulage over any other system are:—

(1) The small number of men required for a given quantity of coal.

* *Trans. Fed. Inst.*, vol. viii., page 377; vol. ix., page 178; and vol. x., page 418.

(2) The slow speed prevents any loss of load on the journey, reduces to a minimum the risk of breakage of wheels and axles, and avoids the consequent mischief attendant on such accidents, when the train is travelling at a high speed.

(3) The draw-bar of each tub has only the weight of one tub to carry, whereas in trains the draw-bar of the first tub has perhaps a weight of 20 or 40 tubs pulling against it, and the same remark might be made as to the couplings.

(4) The steady and continuous supply of loaded tubs to the shaft.

(5) In an incline with varying gradients (where main-and-tail rope might be used) the whole weight of the journey was distributed equally over the whole length of the rope, which was a great advantage to the prime motor and the whole of the haulage-tackle.

The endless-rope system was so generally applicable that he thought one-half of the power now used in other systems might be dispensed with if this system were introduced.

Mr. M. H. Mills remarked that in many mines considerable difficulty was met with in keeping the roads sufficiently wide for endless-rope haulage. In a colliery, near Barnsley, it had been found not advisable to adopt endless-rope haulage owing to the difficulty of maintaining wide roads. There was a little water to contend with on the roads which, owing to a clay bottom, caused the floor to "creep." In these days when electricity was so much in vogue, he thought that they were liable to neglect the advantages of the use of compressed-air. Some years ago, in Durham, he saw in operation a system of haulage by compressed-air locomotives, each drawing from eight to twelve tubs up a moderate gradient. In cases where it would be dangerous to use electricity, such locomotives might be used in preference to endless-rope haulage, especially where it was not very easy to maintain wide roads.

Mr. Granville Chambers (Digby collieries) said that ten years ago he had experience of the use of a compressed-air locomotive at a colliery in Staffordshire. It was found that one locomotive would do the work of 3½ horses on a fairly easy gradient. There were, however, very great disadvantages attaching to its use: the road had to be constantly repaired, and the roof and sides required a great deal of attention. They only worked it for a short time. The use of compressed-air locomotives underground, in his experience, was a failure.

DISCUSSION UPON MR. A. H. STOKES' PAPER ON "PHOTOMETRIC VALUES OF, AND NOTES UPON, VARIOUS ILLUMINANTS USED IN MINES."*

Mr. STOKES said that the Abel tester was the most efficient apparatus for ascertaining the flashing-point of mineral oils. There was a rough and ready test—the open test, but if such test were employed 30 degrees must be deducted from the results obtained.

Mr. L. W. DE GRAVE (Derby) wrote that the labour and care involved in the preparation of this most interesting paper could only be realized by those who had carried out similar tests. His own photometric work had been almost exclusively confined to electric lamps (both incandescent and arc) from 0·22 to 10,000 candle-power at various brilliancies.

At the outset, he found that of the many forms of photometer there were comparatively few which, whilst being simple and convenient, were sufficiently accurate. He had tried the arrangement described by Mr. Stokes, namely, a thin paper greased all over with the exception of a spot in the centre. This he gave up, preferring instead the same arrangement reversed, that was to say a plain paper with a greased spot in the centre; those who had not tried the two arrangements might consider it a distinction without a difference, but there was a difference in the ease and exactness of reading. Mr. Stokes had not mentioned what grease he used, although as presumably all the tests were made with the same grease spot the ratios of the lights would be correct. Personally, he found that the colour of the grease made a difference, and after a few trials settled down to a paraffin-wax grease spot, a great advantage being that dust and dirt did not readily adhere to it and could be removed with a brush much more easily than with any other form of grease. Eventually, he gave up the grease-spot photometer altogether, having found, to his mind, the most accurate method to be the use of two blocks of paraffin-wax separated by a sheet of tin-foil so arranged that the standard light illuminated one block and the test light the other (the tin-foil between the blocks making the dividing line); the direction of observation being in a line at right-angles to a line joining the two illuminants, and the adjustment being made until both blocks appeared equally illuminated.

This arrangement answered perfectly, up to about 100 candle-power. For higher powers, he used the Ayrton photometer, in which the two

* *Trans. Fed. Inst.*, vol. x., page 135.

illuminants are made each to throw a shadow (on a screen) of a vertical rod fixed in the apex of a V-frame; the illuminants forming the heels, and adjustment being made by moving the standard light until the shadow of the rod thrown by it appeared as dark as that shown by the test.

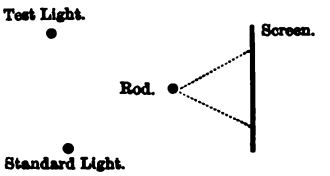


Fig. 1.—The Ayrton Photometer.

The eyesight of the observer had, of course, a great deal to do with the results obtained; this Mr. Stokes had eliminated by taking the mean of the observations of three individuals. It would be interesting, from an oculist's point of view, if Mr. Stokes were to give the individual readings in one or two experiments. There was one other point which had an influence on the readings, and that was colour, more especially in illuminants rich in ultra-violet rays. He did not mean to say that safety-lamps, or even standard candles, were rich in ultra-violet rays, unfortunately they were not, being almost altogether orange; what he meant was that some people's eyes were more sensitive to one colour than another, so that to eliminate this source of error it was advisable to take the mean of four readings, (*a*) with the naked eye, (*b*) looking through a red glass, (*c*) blue glass, and (*d*) yellow glass (taking care not to use flashed glass, which is deceptive). For still greater exactness, a combination of Mr. Stokes' method with the above would answer, that was to say adopt the mean of the four readings of three individuals.

His remarks were not to be taken as throwing doubt on Mr. Stokes' tests, for as a matter of fact the figures in Mr. Stokes' paper tallied very closely with some made by himself some years ago with bonneted Clanny and Marsaut lamps burning the mixture recommended by the Royal Commission, namely, 0·43, as against 0·44 candle power.

The meeting was then closed.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, FEBRUARY 15TH, 1896.

MR. THOMAS DOUGLAS, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on January 25th and that day.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. CHARLES JEFFERSON CLARK, Mining Engineer, P.O. Box 52, Buluwayo, Matabeleland, British South Africa.

Mr. ROBERT CLARK, Mechanical Engineer, Singareni Collieries, Hyderabad Deccan Company, Limited, Secunderabad, India.

Mr. DAVID DRAPER, Geologist and Mining Engineer, P.O. Box 460, Johannesburg, South African Republic.

Mr. M. EISSLER, Mining Engineer, 165, Pitt Street, Sydney, New South Wales.

Mr. GEORGE ROWLAND FEARBY, Mining Engineer and Reporter on Mines, Union Bank, Coolgardie, Western Australia.

Mr. WILLIAM FRECHEVILLE, Mining Engineer, Claremont, Nutfield, Redhill, Surrey.

Mr. JAMES M. HAMILTON, Mining Engineer, El Paso, Texas, U.S.A.

Mr. DUNCAN STUART JOHNSTON, Mine Manager for the New Spes Bona Gold-mining Company, P.O. Box 116, Johannesburg, South African Republic.

Mr. CARLOS F. DE LANDERO, Mining Engineer, c/o Real del Monte Company, P.O. Box 1, Pachuca, Mexico.

Mr. HENRY LOUIS, Professor of Mining, and Mining Engineer, Durham College of Science, Newcastle-upon-Tyne.

Mr. HERBERT T. MARKS, Consulting, Mining, and Mechanical Engineer, P.O. Box 1941, Johannesburg, South African Republic.

Mr. HENRY WILLOCK RAVENSHAW, Mechanical and Electrical Engineer, 110, Cannon Street, London, E.C.

Mr. EDWARD G. STOIBER, Mine Owner, P.O. Box 129, Silverton, Colorado, U.S.A.

Mr. JOHN JAMES WHITEHEAD, Mining Engineer, 5, Cross Street, Manchester.

ASSOCIATE MEMBERS—

Mr. HARRY S. AINSWORTH, Belvedere, Marine Terrace, Geraldton, Western Australia.

Mr. JOHN WILSON ARCHIBALD, Coolgardie, Western Australia.

Mr. C. W. CHAPMAN, Managing Director, the Australian Smelting Company, Limited, 39, Queen Street, Melbourne, Australia.

Mr. E. F. X. COOPER, Stock and Share Broker, P.O. Box 66, Pretoria, South African Republic.

Mr. T. R. GUE, President, Acadia Powder Company, Limited, P.O. Box 520, Halifax, Nova Scotia.

Mr. F. L. INMAN, Poste Restante, Johannesburg, South African Republic.

ASSOCIATES—

Mr. JOHN BROWN, Deputy Overman, 13, West Street, Brandon Colliery, Co. Durham.

Mr. JOSEPH A. DIXON, Back Overman, Ellison Road, Dunston.

Mr. GEORGE STOKER GORDON, Fore Overman, Louisa Terrace, West Stanley.

Mr. EDWARD HERRON, Under Manager, Holly Terrace, Stanley, R.S.O.

Mr. HAROLD TARBUCK, Surveyor, 637, Atherton Road, Hindley Green, near Wigan.

Mr. JOHN URWIN, Under Manager, Inkerman House, Usworth Colliery.

STUDENTS—

Mr. GEORGE PLUNKETT CHAPLIN, Mining Student, Durham College of Science, Newcastle-upon-Tyne.

Mr. CHARLES C. GREENE, Mining Student, South Durham Colliery, Eldon, Bishop Auckland.

Mr. HUGH LATIMER, Mining Student, South Durham Colliery, Eldon, Bishop Auckland.

Mr. FRED. J. RAINE, Mining Student, Cornsay Colliery, Co. Durham.

Mr. THOMAS C. WHITFIELD, Mining Student, Cornsay Colliery, Co. Durham.

DISCUSSION UPON THE "REPORT OF THE PROCEEDINGS OF THE EXPLOSIVES COMMITTEE."*

Mr. A. C. KAYLL read the "Report of the Proceedings of the Flameless Explosives Committee, Parts II. and III.," and illustrated, by means of a diagram, the results of the experiments with the several explosives in the various gaseous and coal-dust mixtures. In conclusion he said that the descriptions of the coal-dust ignitions in the *Report* were somewhat tame. The Committee could only describe the facts without embellishment, and it was difficult for any one (who had not seen it) to realize the terrible intensity of a coal-dust ignition. It had unfortunately been the lot of the Committee to prove a negative, namely, that safety-explosives were not flameless, and were not absolutely safe. He ventured, however, the opinion that the Committee had done no mean service in face of the almost absolute confidence which was placed in safety-explosives at the time when the experiments were commenced. These explosives were very important and very valuable inventions, and they need only compare their safety with blasting-powder or the gelatinous forms of nitro-glycerine to acknowledge that a step forward had been made towards realizing the hopes of perfect immunity from danger when using explosives for mining purposes.

The PRESIDENT said that in the *Report* the words "ignition," "inflammation," and "explosion" were variously used; he asked if these different words were intended to have any relative significance; in one place it was stated that a violent ignition caused "the cannon to recoil for a length of 4 inches."† Was that recoil due to the force of the explosion or was it attributed to the firing of the shot?

Mr. KAYLL said there was no recoil at all from firing the shot. Recoil was produced by the pressure in the tube resulting from the ignition of the dust. The words referred to by Mr. Douglas had no distinctive difference; throughout the *Report* they spoke of "igniting" an explosive mixture, rather than "exploding" an explosive mixture; and there was no intended distinction in the use of the three terms—inflammation—ignition—or explosion.

* *Trans. Fed. Inst.*, vol. viii., pages 227 and 593; vol. ix., pages 115, 206, and ; and vol. x., pages 38, 197, and 492.

† *Report*, page 88.

Mr. A. L. STEAVENSON said he would not attempt for a moment to criticize the final *Report*, but there were one or two points which he would like to emphasize. It was stated that the Coal Mines Regulation Act "enacted that in a gaseous or dusty mine an explosive which cannot ignite gas or coal-dust may only be employed."* It was quite clear from the *Report* that no such explosive was available, and those who were using high explosives were possibly breaking the law. If there were any amendment of the Coal Mines Regulation Act this fact should be borne in mind, and the phrase should be altered to "that could hardly ever ignite coal-dust." There would probably be a conference shortly between the representatives of colliery owners and workmen, and he would recommend that their attention should be drawn to the difficulty which they met with from the workmen themselves in regard to both the payment for and use of high explosives. It was stated that "the possibility of common blasting-powder igniting coal-dust may be accepted, but the conditions necessary to such ignition have yet to be determined,"† and that point must not be lost sight of in any further experiments which might be made. He presumed that the dust in all cases was dry and as fine as it could be. It would be impossible, he supposed, to test the fineness of the dust, but no doubt it was of impalpable fineness. The *Report* seemed to show that no safety-explosive was safer than another, and he had told his workmen that if there was any one which they preferred he would endeavour to get it for them to use. It was also stated that the "retarded ignitions of explosive mixtures of coal-gas and the point of first ignition of gas mixtures occurring many feet distant from the cannon are interesting features in the enquiry."‡ He supposed that was owing to the particular temperature required to cause an explosion, and that it was only when the flame extended to a certain distance from the hole that it attained such a temperature as would cause the ignition or explosion of the gases or coal-dust. He must congratulate the Committee and Mr. Kayll on the results of their labours.

The PRESIDENT asked whether there was any way in which the results arrived at by the Committee could be compared with those published by other Commissions, the French, the German, the Prussian, etc.?

Mr. KAYLL said that the explosives themselves differed so much, as manufactured and used in this and other countries, that the experiments made by the different Commissions could hardly be said to have been made with the same explosives. Practically, the only experiments

* *Report*, page 84. † *Ibid.*, page 84. ‡ *Ibid.*, page 108.

DISCUSSION UPON THE "REPORT OF THE PROCEEDINGS OF THE EXPLOSIVES COMMITTEE."*

Mr. A. C. KAYLL read the "Report of the Proceedings of the Flameless Explosives Committee, Parts II. and III.," and illustrated, by means of a diagram, the results of the experiments with the several explosives in the various gaseous and coal-dust mixtures. In conclusion he said that the descriptions of the coal-dust ignitions in the *Report* were somewhat tame. The Committee could only describe the facts without embellishment, and it was difficult for any one (who had not seen it) to realize the terrible intensity of a coal-dust ignition. It had unfortunately been the lot of the Committee to prove a negative, namely, that safety-explosives were not flameless, and were not absolutely safe. He ventured, however, the opinion that the Committee had done no mean service in face of the almost absolute confidence which was placed in safety-explosives at the time when the experiments were commenced. These explosives were very important and very valuable inventions, and they need only compare their safety with blasting-powder or the gelatinous forms of nitro-glycerine to acknowledge that a step forward had been made towards realizing the hopes of perfect immunity from danger when using explosives for mining purposes.

The PRESIDENT said that in the *Report* the words "ignition," "inflammation," and "explosion" were variously used; he asked if these different words were intended to have any relative significance; in one place it was stated that a violent ignition caused "the cannon to recoil for a length of 4 inches."† Was that recoil due to the force of the explosion or was it attributed to the firing of the shot?

Mr. KAYLL said there was no recoil at all from firing the shot. Recoil was produced by the pressure in the tube resulting from the ignition of the dust. The words referred to by Mr. Douglas had no distinctive difference; throughout the *Report* they spoke of "igniting" an explosive mixture, rather than "exploding" an explosive mixture; and there was no intended distinction in the use of the three terms—inflammation—ignition—or explosion.

* *Trans. Fed. Inst.*, vol. viii., pages 227 and 593; vol. ix., pages 115, 206, and 274; and vol. x., pages 38, 197, and 492.

† *Report*, page 88.

expenditure of time and money had been amply repaid by the important and definite conclusions which the Committee had been able to announce as the result of their labours, and, after a careful examination of the several *Reports*, he was satisfied that these conclusions are justified and true.

The particular phase of the experiments to which exception can be, and has been, taken is the fact of the very small charges of explosive which were used, but that method had this advantage, viz.: that stemmed shots could be used, and by this means the Committee were able to show the salutary effect of stemming.

It is true that we are left somewhat in the dark as to what might happen if working charges of, say, from 12 to 20 ounces were fired with conditions similar to those under which the smaller charges were used. On this point Mr. Winkhaus' experiments, some of which he had the pleasure of witnessing, throw some light; the impression they left was that as the weight of charge was increased so the liability to ignition was increased.

It is suggested in the *Report** that even an explosive mixture of pit-gas and air becomes more dangerous and more easily ignited if there be mixed with it quite small quantities of coal-dust. In corroboration of this opinion, it is mentioned that one or two of the explosives which, when stemmed, failed to ignite mixtures of air and fire-damp, did ignite similar mixtures when coal-dust had been added. Now, it is well-known that an atmosphere of air and fire-damp, in itself below the explosive point, becomes explosive by the addition of coal-dust, indeed it has been pointed out by Sir Frederick Abel that this result happened when the dust is of a non-carbonaceous character. Sir Frederick explained why this was so, but he did not remember the explanation at the moment; the phenomenon was no doubt due more to a mechanical than a chemical cause, and would operate in both explosive and non-explosive atmospheres alike.

It is important to notice that the experiments of the Committee show† that comparatively small quantities of coal-dust will, under certain conditions, produce an explosive atmosphere, and they point out that this is contrary to the view generally held by mining engineers. He (Mr. Hall) had often heard it stated by experts that the air in a colliery would need to be so heavily charged with dust before any great danger could exist as to be unbearable to those working in it; personally, he had always opposed this view because he was quite satisfied that several of the most violent explosions in the experimental pit at White Moss occurred when the air in the shaft was very lightly charged with dust.

* Page 90. † *Report*, page 84.

Those who carefully studied the final *Report* of the Committee could not fail to be convinced that in dry coal-dust we have to reckon with an agent capable of even more disastrous effects than fire-damp itself, and he thought that he was justified in stating that the *Report* affords a most decisive confirmation of what is known as the "coal-dust theory."

He would now refer to one statement which did not appear to be quite accurate:—It was stated that "The possibility of danger in mines resulting from the use of blasting-powder being established, led to the stringent clauses in the Coal Mines Regulation Act, 1887, where it is enacted that in a gaseous or dusty mine an explosive which cannot ignite gas or coal-dust may only be employed."* Now, as a matter of fact, blasting-powder or any explosive may be used under the existing Act of Parliament in a gaseous or dusty mine, the only condition precedent to using blasting-powder is, that there must not be a dangerous accumulation of fire-damp within the ventilating district where it is proposed to be used. If the mine be dusty, blasting-powder may be used after wetting the locality of the shot. It is true that if these conditions were always rigidly adhered to all would end well, but the practical difficulties to be overcome in order to ensure these conditions are great. Hence, so long as dangerous explosives are admitted into mines of a gaseous and dusty character there will continue to be disasters from time to time.

In conclusion, he would respectfully draw the attention of the Committee to the very mild expression of opinion that "high explosives are less liable than blasting-powder to ignite inflammable mixtures of air and fire-damp, air and coal-dust, and air, fire-damp, and coal-dust."† On reading this paragraph he asked himself the question—Is this all? "Less liable." By reference to Table K,‡ where details are given of experiments with stemmed shots of the various explosives fired into coal-dust in suspension, it will be found that 100 shots were fired with safety-explosives without a single ignition of dust, whilst under precisely the same conditions out of 7 shots with gunpowder 6 ignited the dust. The whole *Report* is strong evidence of the danger of such explosives as blasting-powder, and the comparative safety of the safety-explosives in pit-gas, and air or coal-dust, when fired with stemming, and when we remember that blown-out shots with the safety-explosives are, he believed, unknown, this view is much strengthened.

Mr. H. BIGG-WITHER (Wigan) wrote with regard to the communication, *re* analysis of roburite, made by Prof. Bedson.§ The maximum

* *Report*, page 84. † *Ibid.*, page 110. ‡ *Ibid.*, pages 123-127.

§ *Trans. Fed. Inst.*, vol. x., page 40.

quantity of chlorine allowed to be used in roburite could be easily calculated, taking as data (*a*) the definition of roburite contained in the *Annual Report of H.M. Inspectors of Explosives*, and (*b*) the proportions of ingredients used.* There still appears to be a great misconception on this chlorine question, which may have arisen from the fact that the substance hitherto used in the manufacture of roburite has been described, perhaps wrongly, as "chloro-dinitro-benzole," instead of "chlorinated dinitro-benzole," which is the official definition in the list of authorized explosives. He (Mr. Bigg-Wither) gave below copies of the schedule attached to the license of the Roburite Explosives Company, defining from time to time the composition of roburite as authorized to be manufactured by the Secretary of State :—

I.—Previous to July, 1888 :—

Consisting of a mixture of nitrate of ammonium and thoroughly purified chlorinated dinitro-benzole; provided that such chlorinated dinitro-benzole shall not contain more than 4 parts by weight of chlorine to every 100 parts by weight of the chlorinated dinitro-benzole.

II.—After July, 1888 :—

Consisting of a mixture of nitrate of ammonium and thoroughly purified chlorinated dinitro-benzole, with or without the addition of thoroughly purified chloro-nitro-naphthalene and chloro-nitro-benzole; provided (*a*) that such chlorinated dinitro-benzole shall not contain more than 4 parts by weight of chlorine to every 100 parts by weight of chlorinated dinitro-benzole, and (*b*) that the proportions of chloro-nitro-naphthalene and chloro-nitro-benzole shall not amount to more than 2 per cent. and 5 per cent. respectively of the finished explosive.

III.—Until recently :—

Consisting of (*a*) nitrate of ammonium, with or without an admixture of nitrate of sodium and neutral sulphate of ammonium, or either of them, provided that the amount of nitrate of sodium shall in no case exceed 50 per cent. of the total amount of nitrates present; and (*b*) thoroughly purified chlorinated dinitro-benzole, with or without the addition of thoroughly purified chloro-nitro-naphthalene and chloro-nitro-benzole; provided (1) that such chlorinated dinitro-benzole shall not contain more than 4 parts by weight of chlorine to every 100 parts by weight of chlorinated dinitro-benzole; and (2) that the proportions of chloro-nitro-naphthalene and chloro-nitro-benzole shall not amount to more than 2 per cent. and 5 per cent. respectively of the finished explosive.

In No. I. definition, the organic substance is defined as chlorinated dinitro-benzole with a maximum of 4 parts by weight of chlorine to every 100 parts. In No. II. license, leave is granted to add, if desired, either chloro-nitro-naphthalene and chloro-nitro-benzole, limited to certain quantities. This permission was granted owing to the difficulty of chlorinating dinitro-benzole directly : nitro-naphthalene or nitro-benzole,

* *Report*, page 16.

which are more easily chlorinated, being used as carriers of chlorine to chlorinate the dinitro-benzole, the quantity again being fixed at 4 per cent. In No. III. license, the chlorinated dinitro-benzole still remains the same, but permission was granted to add other substances with nitrate of ammonium, and when other substances were added the definition was given separately as roburite No. 2, and the definition under No. III. alone was named roburite No. 1.

For the past six years, roburite has consisted of chlorinated dinitro-benzole and nitrate of ammonium, the addition of the other substances having been discarded after experiments with some of the various possible mixtures. The only real alteration, besides varying the proportions of the two components, chiefly in the direction of increasing the weight of nitrate of ammonium, has been the substitution of nitro-naphthalene in 1892 as the chlorine carrier for nitro-benzole, which was used during the first few years.

The above details have been given at some length, in order that there should be no further misconception on the subject. It will be seen that from the very first the manufacturers have been limited to a maximum of 4 per cent. of chlorine in the chlorinated dinitro-benzole. Taking, then, the proportions given in the Committee's *Report*, 13 parts of chloro-dinitro-benzole* and 87 parts of nitrate of ammonium, the maximum quantity of chlorine permissible would only be 0·52 per cent. in the finished roburite instead of about 2·2 per cent., which appears to have been the idea with some people.

Mr. J. S. MARTIN (H.M. Inspector of Mines, Bristol) wrote, hoping that the conclusions of the Committee, as well as the unfortunate experience gained by repeated accidents, would have the effect of causing those interested in coal-mines to realize the gravity of using any but the most approved safety-explosives, as well as the use even of these when the ordinary shifts are employed in the mine. The Camerton explosion in 1893, and the Timsbury explosion in 1895 (upon which he had specially reported), both occurring in absolutely non-fiery mines, had converted him very strongly to this view, and even these views had been strengthened by the experiments (which, accompanied by his colleague, Mr. H. Hall, he had had the pleasure and advantage of witnessing at Schalke, near Gelsenkirchen, Westphalia, in October last) conducted by Mr. Winkhaus.

He believed that neither managers nor under-officials realize what a small quantity of coal-dust is sufficient, under certain conditions, to

* It should read "chlorinated dinitro-benzole."

create very serious results in connexion with shot-firing. He (Mr. Martin) had only comparatively recently done so.

Mr. J. G. WEEKS asked whether the Committee were of opinion that coal-dust from a shallow mine would have the same effect as that from the deep, dry and dusty mines of Durham.

Mr. J. L. HEDLEY (H.M. Inspector of Mines, Newcastle-upon-Tyne) said that the Committee had not made special experiments on coal-dust; they were simply appointed to ascertain whether safety-explosives would ignite coal-dust. Mr. Weeks probably assumed that the dust from the deeper mines in Durham would be more explosive or more liable to ignition than the dust from the shallower mines. That might be so or not, but the Committee had not made any experiments as to the different kinds of dust, for the reason that they had not had time and were not instructed to do so.

Mr. J. G. WEEKS said it might possibly follow, then, that some of the explosives, which had fired the coal-dust used in the experiments, would have proved perfectly safe if applied to Northumberland coal-dust. He (Mr. Weeks) had heard the Durham and Northumberland collieries described, so far as gas was concerned, as being divided into three zones or belts. In the first of which, the shallow pits, there was no gas; in the second, somewhat deeper, gas was found; and in the third, or lowest, there was less gas, where, owing to the depth, the temperature was greater. There might possibly be something similar, as regards the liability of dust to ignition from mines of various depths, arising from the quality and nature of the dust and of the coal-seams.

The PRESIDENT said that the reports of the various foreign Commissions were carefully worded, and like that of their own Committee said that certain things might occur. His own experience led him to be very doubtful as to what might happen with coal-dust alone. His experience went back to the time when they were working with corves and cranes at Wallsend; when shots were fired in coal-dust, and when the light from the lamp gave off scintillations in every direction, and he had often been surprised that explosions did not occur almost daily. From the *Report*, it appeared that a great many of the ignitions did occur with dust in suspension, and not with dust *in situ*. They knew very well that in the deep mines, large quantities of dust were continually in suspension, but he now thought that any single colliery might be picked out as essentially dangerous, and the use of explosives might be prohibited. Some

collieries were certainly more dangerous than others, and the condition of the mines should be taken into consideration in saying whether explosives of a defined kind should be permitted. This question was not considered in the *Report* of the Committee, but it was a subject to be taken into account in considering what explosives should be used.

Mr. M. W. PARRINGTON, referring to the President's remarks and the observations that he had made with regard to coal-dust in suspension in deep mines, said that the question had been raised in his own mind as to the conditions under which coal-dust became most dangerous; and the conditions as to the volume of air passing at the time. It appeared to him that several serious explosions had been attributed to shots fired in airways where large volumes of air had been passing, and it was a question yet to be decided whether that was not the most dangerous part of a mine in which to fire a shot, where there was coal-dust, and he thought this pointed to the great desirability of testing coal-dust under different velocities of air-current in which it was suspended. He, like the President, had had many opportunities of observing the conditions in broken juds in deep mines, where the atmosphere was very thick with suspended coal-dust, and yet did not appear to be dangerous, so far as could be judged from the effects on the flame of a safety-lamp.

Mr. J. G. WEEKS said that at certain collieries some hundreds of shots of blasting-powder had been fired daily in coal and stone during the last forty or fifty years without an explosion occurring. As ignition only took place occasionally even with safety-explosives after many previously unsuccessful trials of them by the Committee, it might naturally be inferred that a peculiar set of special conditions, as yet unknown, was needed to produce such ignitions; these conditions were not likely to occur in practice, while mining in pits of ordinary depths judging from their past immunity from accidents. Consequently prohibition of any explosive, should therefore be sectionally and not universally applied.

The PRESIDENT said that he had listened to the reading of the *Report* with great pleasure, and more especially owing to the happy manner in which it had been illustrated by Mr. Kayll. He was sorry that Mr. W. Lishman, the chairman of the Explosives Committee, had been compelled, at an early period, to retire from taking an active part in the work of the Committee, but Mr. Hedley as vice-chairman had performed his duties most efficiently, and to that gentleman and to Mr. Kayll, who had brought before them a *Report* which would be of great value in the

future, their best thanks were due. He had pleasure in moving that the thanks of the Institute be given to the members of the Flameless Explosives Committee for their valuable and exhaustive report, and he especially congratulated Mr. Hedley and Mr. Kayll upon the happy conclusion of their labours.

Mr. M. W. PARRINGTON seconded the proposal, which was cordially adopted.

Mr. J. L. HEDLEY, replying on behalf of the members of the Committee, said that in the absence of the chairman (Mr. W. Lishman) he could only return the sincere thanks of the Committee for the expression of approval of their work during the last four or five years. He felt sure that the members of the Committee would feel gratified to know that their services, whatever they may have been, had not only been appreciated by the members, but by mining engineers at a distance, as had been testified by the communications read that day. The Committee had done their best in the matter; they were willing to admit there were many things that they might have done, but time was short, and they were limited to the work which they were appointed to perform. It was possible that in the future there might be many questions requiring attention arising from this *Report*. He himself could not always devote his time, but there were other members of the Committee who would be only too pleased to give their services to the welfare of the Institute in any direction that they might be requested. Personally, he was extremely obliged to the President for his kindly remarks, and he thought that he was right in saying that every member of the Committee would be equally thankful for the friendly appreciation of their services.

Mr. A. C. KAYLL briefly responded.

The meeting was then closed.

SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,
HELD IN THE MASON COLLEGE, BIRMINGHAM, FEBRUARY 6TH, 1896.

MR. R. S. WILLIAMSON, VICE-PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and of the Council Meetings were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. WILLIAM HENRY CHAPMAN, Mining Engineer, Cradley.
Mr. GEORGE HOLLOWAY, Under-manager, Hamstead.

DISCUSSION UPON MR. I. MEACHEM'S PAPER ON "ELECTRIC-POWER PLANT AT HADEN HILL COLLIERY."*

Mr. I. MEACHEM, Jun., said that he stated at the end of his paper that the electric installation had not been in operation a sufficient length of time to justify his entering into the financial details. The installation has now been at work about six months, so that it is possible now to judge of the merits of the plant and to compare it with steam-power.

The total cost of the installation was £2,289, including the cost of the haulage, lighting, pumping and ventilating-plant, machinery, and formation of motor-house in the mine, the adaptation of a former winding-engine to drive the dynamos, and all labour connected with, and incidental to, the erection of the plant. It is estimated that a steam-driven plant for haulage, pumping and ventilating purposes would cost about £1,200, or £1,089 less than the cost of the electric-plant.

* *Trans. Fed. Inst.*, vol. x., page 178.

The comparative advantages of the two systems are as follows :—

	Steam power. £	Electric-power. £
Saving per annum—		
Candles used in pit	—	73
Lighting pit-bank, engine-houses, workshops, etc.	—	30
Labour employed in pumping water	200	200
Endless-rope running down shaft and along haulage-road to motor-house	—	50
	£200	£353
Less 7½ per cent. renewals and depreciation of electric-plant	—	171
Less 10 per cent. renewals and depreciation of steam-plant	120	—
Net saving per annum	£80	£182

This statement shows a difference in favour of electricity of £102 per annum. He (Mr. Meachem) had taken 7½ per cent. per annum as representing the cost of renewals and of the depreciation of electric-plant, an amount in excess of what is actually the cost in a mine where the system has been at work for some years, but the experience at Haden Hill colliery justifies its adoption; with steam plant, at least 10 per cent. is needed, especially where a long range of steam-pipes is in use.

The preceding statement, however, does not represent all the advantages. Steam-haulage was used previous to the adoption of electric-haulage, and, at that time, although the face of work was much nearer, not more than 400 tons per day on an average could be brought to the shaft; but at present, the workmen at the main junction, at the first left-hand road (Fig. 1, Plate IV.), easily manage 500 tons per day. This considerable increase can be accounted for (1) owing to the superior light, the workmen are able to handle the tubs of coal at the main junction much more expeditiously than when the candles and oil-lamps were used; and (2) by the smoothness and regularity of the working of the rope. There is an accompanying reduction of cost equal to 3·33d. per ton, or about £40 per week, and the ventilation affords satisfactory results. In addition to the number of lights on the surface, given in the paper, the canal-wharves are lighted with eleven 50 candle-power lamps, and a dwelling-house is illuminated with upwards of forty 16 candle-power lamps.

Since the above costs were calculated, the haulage-ropes have been extended to a distance of 840 feet in No. 1 district and of 1,000 feet in No. 2 district, both extensions being in the direction of the dip of the mine.

The chief advantages of the installation are the economical division and distribution of the power and its reliability, there being but comparatively few parts liable to get out of order. Altogether there is every reason to be satisfied with the result, and it is the opinion of the writer, where a new colliery plant is about to be erected, that there should be one central generating-station, from which the power can be economically applied by means of cables wherever it is required.

Mr. S. Mavor wrote that there were several features of the electric plant at Haden Hill colliery which it might be of interest to discuss. The curve on the diagram (Fig. 2, Plate IV.) indicates the violent and frequent fluctuations of the load upon the haulage-motor and dynamo. The fluctuations, as Mr. Meachem said in his paper, are largely due to the coupling of the jig-chain with its load to the haulage-rope. Most dynamos and motors (although sparkless when the brushes are adjusted for any given load) will begin to spark if this load be materially altered, unless the brushes be altered to suit the new conditions. It would obviously be impracticable to alter the brushes to suit the variations of current shown on the diagram; owing to the brushes being in a fixed position they would spark, and the commutator would then become roughened, and require probably frequent turning in a lathe. The machines in use at Haden Hill colliery have the important advantage that they allow of a fixed position of the brushes for very wide variations of load, and the commutators are, therefore, kept smooth and free from cutting and sparking, and the brushes are not burnt. This is a point which does not greatly concern electrically-driven pumps or fans (which absorb power at a uniform rate), but is a really important matter in regard to haulage, and in the case of single rope-haulage the conditions are still more severe. These motors drive single rope-haulage gear equally well, and in some cases have run many months under the most trying conditions without the brushes being touched.

The haulage and pumping-motors at Haden Hill are of the enclosed type, being entirely covered by a cast-steel casing, which also forms the magnetic circuit. This type of motor has been specially designed for mining work, so as to afford protection against accidental damage to the coils, and against dust and moisture, which are the usual sources of trouble accompanying the use of electric machinery underground. The following table shows the losses in the various stages of transmission and the total efficiency :—

	Power Delivered. Horse-power.	Efficiency. Per Cent.	Approximate Loss. Horse-power.	Percentage of Total Power Delivered.
Dynamo receives ...	32·5	91	3·0	100
Cable ,, ...	29·5	92	2·5	91
Motor ,, ...	27·0	91	2.5	83
Gearing ,, ...	24·5	85	3·7	*76
Ropes ,, ...	20·8	—	—	64

* In comparing the efficiency of electrically-driven haulage with haulage driven by a steam-engine at bank, the loss of 15 per cent. in the gearing should be eliminated, as gearing would be required at the steam-engine to reduce the piston speed to that of the rope-pulleys. If the electric generating-plant were erected close to the shaft, the loss in the cable would be reduced to about 4 per cent., which would make the efficiency of the electric arrangement about 80 per cent.

The cables at the Haden Hill colliery are of the concentric type, lead-covered and armoured, and with the return or outer conductor not only uninsulated, but connected definitely to earth. The switches, fuses, etc., are all enclosed in cast-iron boxes, which boxes and the casing of the motor are also connected to earth. The inner or live conductor, which is over 400 volts above the potential or earth, is completely enclosed in a metallic armouring, sheathing, or casing. And this sheathing (while it protects the miners from accidental contact with the live conductor) being itself connected to earth may be freely handled by anyone in the mine. A further advantage afforded by concentric wiring is that the accessory fittings can be readily made waterproof, and of much more substantial and mechanical types than is possible with double wiring. The benefit of having a waterproof system of wiring and fittings, where these are exposed to the weather at the surface and buildings, and in the mine where moisture is encountered must be obvious.

It may also be noted that the lamps used are of the 200 volts type, the recent introduction of which has made it possible to reduce the section of the lighting cables to one-fourth, for transmission to a given distance with a given loss, and this without the addition of any complication in the arrangements.

The satisfactory results, as indicated by Mr. Meachem's paper, which have followed the adoption of electric transmission of power at Haden Hill colliery, are due to the whole apparatus being kept in first-rate order, and it is a real pleasure to those who can appreciate such matters to see machinery running under such conditions. The management of electric machinery does not require highly skilled attendants, but it does require careful and intelligent attention, and above all it requires cleanliness.

Ir. HENRY LEA, C.E., said that he had had the pleasure since the last ing of paying a visit to Haden Hill colliery and of inspecting the e of the electric plant. The arrangements were such as would strike ne favourably, the working of the plant left little or nothing to be ed, and the simplicity of the parts and the ease of control were rkable. Compared with the use of an underground steam engine, was an absence of heat, of leakage of steam, and of condensed :, which would have been inseparable from the use of a steam-power . While he was underground, the electric energy varied from full r down to one-fifth of full power, and there was scarcely any ring at the brushes of the motor, although they were not readjusted ıe varying load. The sparking, then seen, was evidently due to the ɔrushes not being diametrically opposite one another, for after they been set diametrically opposite, there was no sparking. The iron g containing the resistances was worthy of notice, being so arranged the return circuit that should any accidental contact with the ior of the case occur the latter would only receive the difference of ge between the two portions of the resistance-coils and not the working voltage, consequently no danger could ensue to anyone.

ı long experience with concentric cables enabled him to state that erly fixed, they and their accessories formed a perfectly waterproof m, which might be played upon with a fire-hose, and no leakage d result.

Ie did not think that the starting-and-stopping switch for the motor ıarranged on the most modern principles, so as to obviate the risk of ring down the insulation of the field-coils and of volt-meters when nagnetizing circuit was suddenly broken by opening the switch.

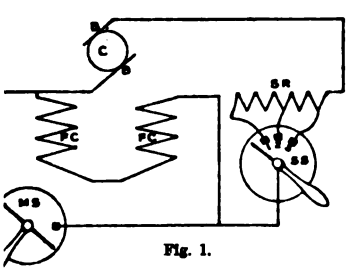


Fig. 1.

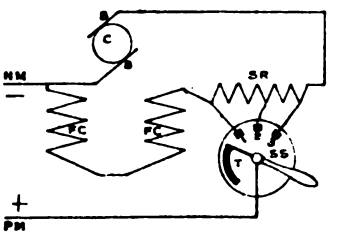


Fig. 2.

Ie produced two diagrams (Figs. 1 and 2) to illustrate the slight differ- in the connexions which would effect this very desirable result. Fig. 1 red the old way of connecting up and Fig. 2 the new way. (The

same letters of reference were used in each figure): *C*, commutator of the motor; *B B*, brushes; *F C*, field-coils; *N M*, negative main; *P M*, positive main; *M S*, main switch; *S S*, starting-switch; and *S R*, starting resistance.

In Fig. 1, when the main switch *M S* is closed the current passes through the field-coil *F C*, and the magnetic field is set up. When the starting-switch *S S* is closed on to the first contact a moderate starting current (determined by the amount of starting-resistance) also passes through the commutator *C*, and the armature revolves. When the starting-switch *S S* is passed on to the second and then to the third contact, the starting-resistance *S R* is first partially and then wholly cut out, and full speed is attained. If, in order to stop the motor, the two switches be opened, the field circuit is broken, and the high voltage current set up by the dying out of the magnetism of the field-magnets is very liable to break down the insulation of the field-coils *F C*, and to damage any volt-meters which may be connected.

To obviate this defect, the main switch *M S* (Fig. 1) must always be opened first. Then a complete metallic circuit is left through the field-coils *F C*, the starting-resistance *S R*, the brushes *B B*, the commutator *C*, and the armature, and the magnetic current in the field-coils *F C*, being opposed by the counter electro-motive force in the armature, dies harmlessly away as the armature gradually ceases to revolve.

There was, however, the disadvantage of having to move two switches for starting, and the risk of burning the brushes should the main switch be turned on before the starting-switch has been placed back to the first contact. Hence the arrangement in Fig. 2 was adopted.

In Fig. 2, one end of the field-coils *F C* is connected to No. 1 contact of the starting-switch *S S*, and a tail-piece *T* is added to the starting-switch. The effect is that with only one switch, the whole of the operations described in relation to Fig. 1 are performed, but when the starting-switch *S S* is opened to stop the motor the complete metallic circuit is maintained, and the switch must of necessity be closed upon the first contact in order to start the motor.

The CHAIRMAN said that he had listened with considerable interest to the discussion. After an extended test of the steam and electric systems he had, however, yet to be convinced that steam-engines fixed on the surface with ropes taken down the shafts could be beaten by any other system.

Mr. MEACHEM said that the cost of labour in connexion with the installation was 0·47d. per ton.

Mr. E. J. Bailey had no doubt that electricity could be used as an economical power where the distances were very great. One thing, however, was against the use of electricity in fiery mines, and that was the sparking of the brushes of the motor. It was possible to reduce sparking to a minimum by the attendant giving proper care to the brushes and keeping them properly adjusted, but this was a matter that could not be left to the care of a workman, and motors must be made safe to work where safety-lamps are used.

Mr. F. Brown (Walsall) said that unfortunately for the electrical engineer, there was a considerable amount of truth in the statement that wire-rope haulage, where the situation is suitable and the distance is not great, is considerably more efficient and less expensive in the first place than electrical haulage can be; but when the distance from the source of power is very considerable and under special conditions, such as occur at Haden Hill colliery, there is a large and useful field for the application of electric power. The last speaker has pointed out what he considers a source of danger in using electricity under the circumstances most favourable in other respects, viz., the danger of firing inflammable gases from the sparking of the brushes or switches when the motors are working in the mine at a distance from the shafts. As motors were first constructed this danger did occur, but there are motors now in the market of more than one type that can be absolutely guaranteed as free from danger in this respect, and would be quite as safe as an ordinary safety-lamp when working in an inflammable mixture. He (Mr. Brown) had also heard the point discussed that there is danger of the wires being broken by falls of the roof or other causes, and that at the immediate point of rupture a heavy sparking would occur if current were passing at the time. This danger, however, can be obviated by keeping the wire at the bottom of the roadways, and if necessary burying them: there is then practically no danger of mechanical damage from any sudden fall of the roof or sides of the roadway.

He (Mr. Brown) desired to emphasize the remarks made by Mr. Henry Lea as to the necessity for improving the switching arrangements, such as have usually been employed on the starting and stopping of motors. He had been several times troubled with the evil effects spoken of by Mr. Lea, who showed the members a ready means of rectifying this difficulty. It should, however, be known that these improvements have been carried out through Mr. Lea's suggestions; he was one of the first to realize the necessity for the alteration, and, owing to his suggestions, switches had been devised that obviate the serious defects, which he insisted should be removed.

Concentric wiring, with an insulated conductor inside for high-tension currents, is absolutely necessary for many situations in the workings of mines, but he (Mr. Brown) thought that, where possible, naked conductors hanging in the shaft should be used, as they are very much less costly and entail less trouble in maintaining them in efficient working order. In several cases in the immediate neighbourhood, concentric cables have been damaged by the constant dripping of the water at the point where they turn from the shaft into the mine. Several covered cables have been replaced by naked copper-wire, suspended from porcelain insulators, and an intelligent workman who has charge of the lighting and signalling arrangements can readily keep the naked copper conductors in order, as they are visible throughout their length and readily repaired if, through any fall in the shaft, they accidentally get broken.

The working of the electric plant at Haden Hill colliery has proved satisfactory, and he (Mr. Brown) believed that, in many places where power was required in small units, electricity will be found convenient and economical. A very noticeable feature in its favour is the extreme portability and convenience of the conductors, enabling a small pump to be moved from one part of the mine to another with a minimum amount of labour and time, in comparison with the removal of a pump driven by steam, compressed air, or rope-gearing.

The meeting was then closed.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE CHRISTIAN INSTITUTE, GLASGOW, FEBRUARY 12TH, 1896.

MR. GEO. A. MITCHELL, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. JOHN SAMPSON, Wellsgreen Colliery, Windygates.
Mr. WM. MCLEAN HOMAN, 719, Great Western Road, Glasgow.

ASSOCIATE MEMBERS—

Mr. HENRY H. WARDE, 196, St. Vincent Street, Glasgow.
Mr. MATTHEW FRIER FINDLAY, 41, Ann Street, Glasgow.
Mr. JAMES SCOTT ANDERSON, 53, Waterloo Street, Glasgow.

ASSOCIATE—

Mr. ALEXANDER MILLAR, Niddrie Cottages, Portobello.

STUDENT—

Mr. JAS. C. HOWARTH, 2, Lendel Terrace, Paisley Road, Glasgow.

DISCUSSION ON MR. ROBERT FISHER'S "NOTES ON MINING IN PORTUGAL."*

Mr. FISHER, in reply to a question put at last meeting, said he had not seen sufficient area exposed to give an opinion on the seam which appeared to cut through the strata. He had the opportunity of observing it for a length of 60 feet, and there was no change. The coal was

* *Trans. Fed. Inst.*, vol. x., pages 121 and 377.

perfectly clean, and the foot and hanging walls were indurated clay. There was, strictly speaking, no "veese" of a fault, but the indurated clay came against the coal.

Mr. J. B. ATKINSON (Glasgow) said that coal was sometimes seen drawn into the "veese" of a hitch for a few feet, but he had never seen a coal-seam traversing rocks at an angle to the bedding for any considerable distance.

Mr. HARDIE (Cambuslang) said that he had had an opportunity when in Edinburgh of seeing plans and sections of veinous coal (albertite) at Brora. He saw samples of the coal, and the anthracitic appearance corresponded exactly with what had been described.

Mr. H. M. CADELL (Bo'ness) said that albertite was not coal, but a kind of natural pitch. The only circumstances under which coal could be found other than in the usual position was in the case of vegetation falling into a fissure and coal then formed from it. In these circumstances a seam of impure coal might occur in a fault. Brora had been referred to, but it had nothing to do with the vein-formation of coal. The Brora coal-seam was found in Jurassic rocks, and he believed that albertite occurred in the Old Red Sandstone, which was separated by a large fault from the Jurassic formation in that district. If not albertite, it must be pitch which had found its way through fissures in the rock. The occurrence of a vein of true coal was impossible.

Mr. J. B. ATKINSON said he had been underground at Brora colliery on three or four occasions, and the coal was an ordinary coal-seam. The Brora coal-field did not extend far inland, only 2 or 3 miles: if there was any albertite, it might occur in the adjacent Silurian rocks.

The discussion was then closed.

DISCUSSION ON MR. H. M. CADELL'S PAPER ON "GOLD-MINING IN THE HAURAKI DISTRICT, NEW ZEALAND."*

The PRESIDENT remarked that Mr. Cadell did not quote the rates of wages paid in New Zealand: perhaps he would give the members this further information. He had just received an account of the average wages of miners paid in one of the mines, it was £127 1s. per annum,

* *Trans. Fed. Inst.*, vol. x., page 389.

and the actual wage earned by a good miner was stated to be considerably more than this sum. Mr. Cadell, referring to the cost of working the Great Martha lode (now the Waihi mine), stated that for some years the company was almost able to pay working expenses with a yield of 4 to 6 dwts. of gold per ton.* At £2 per ounce, which is given as the value of the gold, 5 dwts. is equal to 10s. per ton. Again, Mr. Cadell gives in detail the cost of working at the Waihi mine, and states the cost of mining alone at 10s. 4·66d. per ton, and if the cost of the cyanide process was deleted, the cost of mining and milling would be about 20s. per ton.† These two accounts were not quite consistent, but, no doubt, Mr. Cadell could reconcile them.

Mr. CADELL said that the average rate of wages, excluding labourers, was 8s. per day, or about £110 a year, and skilled labour was higher. With regard to the cost of mining, the information as to the Waihi mine was taken from the *Mines Report* for 1894-95; it showed that the cost of mining was 10s. per ton, the reason being that the ore was harder than in any of the other mines. There were mines in the Thames district where working costs did not, he had been informed, exceed 2½ dwts. per ton. The ore at other mines was not so hard as in the Waihi mine, where the gold occurred in a very finely divided state, so that it required a great amount of stamping to make it fit for the cyanide process.

The PRESIDENT said that Mr. Cadell had not understood his point. The ore at the Waihi mine must have changed its nature if the process now cost 20s. per ton, where previously it was only 10s.

Mr. CADELL said that at the time referred to, the mine did not pay its working expenses. It should be added that the original owners worked another reef in addition to the Martha lode, and he could not give the details of the cost of mining, or of the character of the ore mined by the old company. The latter could not have struggled on for eight years unless they had made ends nearly meet.

Mr. DRON (Glasgow) said that Mr. Cadell had referred to the Big Pump of the Thames district. He understood that a mining company was about to provide a new pump to take the place of the Big Pump,‡ which had become insufficient; and the Government were prepared to pay half the expense to the extent of £20,000, while the company would receive a certain amount from the neighbouring mines for its upkeep. As regards labour conditions, in some gold-fields the mine-owners were

* *Trans. Fed. Inst.*, vol. x., page 400. † *Ibid.*, page 411. ‡ *Ibid.*, page 406.

required to keep so many men at work on each claim, whether they produced gold or not, and this added considerably to the working expenses. The cost of working with 100 heads of stamps in the Witwatersrand varied from 15s. to 30s. per ton; there they employed seven native labourers to one white man, the wage of the native being 30s. per week and of the white man £5 15s. per week.

Mr. CADELL said that the Big Pump was a very large one, draining the country down to a depth of 640 feet, and the object of the new pump was to drain down to a depth of 2,000 feet.* The New Zealand Government, he must say, had acted in a most exemplary way in assisting the development of the Thames gold-field. In New Zealand, the Government, when satisfied that sufficient labour was being employed on a group of leases or claims, did not, as in Western Australia, harass the lessees by insisting on the letter of the law being strictly observed, and work being done on each individual lease. Consequently he was much in favour of New Zealand, whose Government had found out that the gold-mines were one of the best sources of revenue and prosperity to the colony, and deserved all the encouragement that could be given them. There was a tax of 2s. per ounce on gold, the proceeds of which went to the local County Councils, to keep up the roads. The costs in Africa were different altogether from those in New Zealand, because there they had cheap native labour, whereas none but white men were employed in the Australasian colonies, and their wages were 8s. or more per day.

The PRESIDENT asked whether the reefs were rich throughout? He understood that there were "rich pockets," but leaving that out, was there gold throughout the reefs, or were there rich shoots and barren portions of the reefs? Perhaps, also, Mr. Cadell would give the members further information regarding the cyanide process.

Mr. CADELL said that the Waitekauri company dried the ore, put it into the stamp battery, treated it as at Waihi in cyanide vats, and then ran it over amalgamated copper-plates to recover any coarse gold that escaped the cyanide treatment. This system had two advantages over the old method of cyanidation after amalgamation: the fine gold was removed completely by the cyanide solution, and the action of the solution on the coarse gold, left undissolved, had the effect of cleaning it and thus facilitating its amalgamation on the silvered plates. In some cases the ores required to be calcined owing to the presence of antimony and other minerals, which prevented the amalgamation of the gold in the battery. At some places, where 95 per cent. of the gold was recovered in the

* *Trans. Fed. Inst.*, vol. x., Fig. 2, Plate XVI.

stamp battery, the cyanide process was not used. At other places it was found advantageous to use it. In regard to the uniform richness of the ore, it was a disadvantage that the New Zealand reefs were not always uniform; they were often patchy, and hence it was important for companies to acquire large areas with more than one reef if possible, so that richer and poorer parts could be worked together and a good average result obtained. At the Old Caledonian mine, 10 tons of gold were extracted in one year, but it had never paid a dividend since. The great peculiarity of the reefs in the Thames district was that the country rock or "andesite" which looked like common whinstone at certain places had become decomposed and had turned nearly white. The reefs were all of Tertiary age, and occurred in this white rock known locally as "kindly sandstone," but which was really of igneous origin.

The PRESIDENT closed the discussion, and moved a vote of thanks to Mr. Cadell for his paper.

DISCUSSION ON MR. R. W. DRON'S PAPER ON "THE SOUTHERN AYRSHIRE COAL-FIELDS."*

Mr. J. B. ATKINSON (Glasgow) said that Mr. Dron's paper was of a very interesting character, and he wished that they had more papers of the same kind, descriptive of the various coal-fields of Scotland. Mr. Dron, in his classification of the igneous rocks, did not appear to him to be quite correct. The officers of the Geological Survey classified igneous rocks as (1) intrusive, and (2) interbedded. Intrusive rocks embraced all the igneous rocks that had been forced into the strata after these were formed. Intrusive rocks included floating whins, which were sometimes termed interbedded, as well as intrusive dykes. The interbedded igneous rocks proper had been projected up to the surface, and afterwards covered up by sedimentary rocks. There was another point, as to the abandonment of the working of black band ironstone at Lugar.† Mr. Ronaldson informed him that black band ironstone was still extensively worked in the Lugar as well as in the Dalmellington district.

The PRESIDENT said that before Mr. Dron referred to the remarks which Mr. Atkinson had made, he would ask him to explain the origin of the large beds of whin found in Ayrshire. He understood that it was an accepted fact that there was no volcanic action while the Upper Coal-measures were being deposited. Now, they had large areas—hundreds of acres in some parts—of whin of considerable thickness in the Upper Coal-

* *Trans. Fed. Inst.*, vol. x., page 378. † *Ibid.*, page 383.

measures. What was the theory of the deposition of these whins? One could understand the igneous rocks coming up and forcing their way between the rocks for a short distance; but, it was difficult to imagine them covering a very large area in this way.

Mr. DRON said, with regard to intrusive and interbedded igneous rocks, that he had a paragraph written which he had taken out, as Mr. Atkinson, in one of his Presidential addresses, had gone fully into the subject. The intrusive rocks had been interposed long after the coal had been formed. In proof of this fact, that the whin had been interjected after the beds were formed, he had been able to trace a whin in a coal-seam for 300 feet. It was at first half an inch thick, and after a distance of 120 feet increased several inches in thickness, and the coal was burned above and below. When the working place was stopped, the whin was about 3 feet thick and the coal was quite destroyed.

Mr. MARTIN (Niddrie), referring to the paragraph dealing with the Calciferous Sandstone, said Mr. Dron would seem to infer that there were valuable seams of coal under these measures.* He did not think that that was so, as there were only three little seams one of them known as the Houston coal, and some unsuccessful attempts had been made to work them, but they had proved of little value. In the North of Ireland there was a large area of trap rock overlying a very inferior coal-seam, so spongy that it would not burn.

Mr. ATKINSON said that at Dunnikeir in Fifeshire he had observed that the roof of a coal-seam was whinstone, and at a colliery near Blackwood he saw the Lesmahagow gas coal with 3 or 4 feet of blaes as the roof, followed by 3 or 4 feet of intrusive whinstone. It did not affect the coal, and it appeared to be rather difficult to say how it had been intruded without burning the coal. The whole question of the effect of whin on coal-seams was a matter which required exhaustive study and the collection of many details. He did not know any coal-fields more likely to give an opportunity for doing so than those of Scotland. With reference to coal being worked in the Calciferous Sandstone, none had been worked in the eastern district last year, nor had there been any worked in the western district. Some years ago, a few hundred tons had been worked. Practically, the coal in the Calciferous Sandstone was of no value at the present time.

Mr. CLARKE (Annbank) said that anyone reading Mr. Dron's paper would have thought that everybody should rush to Ayrshire for coal.

* *Trans. Fed. Inst.*, vol. x., page 379.

He did not take the sanguine view of the Ayrshire coal-field that Mr. Dron did, but of course that was a matter of opinion. The section (Plate XIII.) given for the Ayr district was not accurate, and could hardly, he thought, have been taken in the district. A seam called in the section the Ayr soft coal, which is generally called the three-dirt coal-seam, is shown as lying 180 feet below the main coal-seam; as a fact, 60 feet would be the average distance. Between the diamond and the splint coal-seams, the jewel coal-seam has been missed out altogether. If these alterations are made, the section will correspond better with others, and also with those of Lanarkshire.

Different opinions were held as to the correlation of the upper coal-seams of Ayrshire with those of Lanarkshire, but he (Mr. Clarke) thought that the best method of comparison was to start with the splint coal-seam as a basis, there being little doubt these were the same in each district. The jewel coal-seam, about 2 feet thick and lying 40 feet above the splint coal-seam, would correspond with the humph coal-seam of Lanarkshire. The diamond coal-seam about 3½ feet thick, and lying 40 feet above the jewel coal-seam would correspond with the main and pyotshaw coal-seams, the diamond coal-seam being really two, joined together in some districts only. The three-dirt coal-seam consisting of three or more seams of coal, in all about 6 feet thick, divided by beds of fireclay, and lying about 90 feet above the diamond coal-seam, would correspond with the ell coal of Lanarkshire, and has all its varying characteristics. Sixty feet above the three-dirt coal-seam, is another called the Crawfordstone or Drongan main coal-seam, about six feet thick, corresponding to the upper ell coal-seam, while about 80 feet above this again is the ell coal-seam, about 2½ feet thick, represented by one of the thin upper seams of Lanarkshire. This is not the usual view taken, but much can be said in its favour.

Mr. Dron mentioned that the Kilwinning coal-seams lying below the splint coal-seam have been found workable in the Ayr district. This must be a mistake, as there is no place, as yet, where they are either worked or workable.

In Ayrshire, unfortunately, there are large bodies of intrusive whin, in the form of dykes and floats, and these, in his (Mr. Clarke's) experience, were exceedingly destructive of the coal-seams. No doubt the effects of whin are extremely varying, and in some instances the burning might only be for a very short distance; but where true hard whin had been intruded the reverse was usually the case, and often large areas are destroyed, unexpectedly far from the disturbing influence.

In regard to the President's remarks on the occurrence of whinstone in his neigbourhood, a bore-hole has been put through 200 feet of whin, where it has been apparently thrust into the Coal-measures, swallowing up some of the coal-seams entirely, and burning others for a long distance below. The section is increased, but not apparently by as much as the total thickness of the whin. This float is, at another place, 150 feet thick, and is suddenly cut off by a fault, which has evidently been produced by the intrusion of the whin itself, as there is no fault in the coal-seam worked underneath. Faults have often a limiting effect on the action of whin, coal being good on one side of a fault and burned on the other.

It might be of interest to the members to state that the famous Water of Ayr hones, or whetstones, occur in connexion with this float. The whetstone is simply a fireclay baked or burned into the condition which renders it so valuable.

He (Mr. Clarke) had also experience of a similar case of burning in a coal-seam to that mentioned by Mr. Dron: a slightly burned rib first appeared and gradually thickened, while, as it thickened, soft spots of white whin began to intermix; farther on, instead of soft white spots, there was hard bedded whin, which increased in thickness until it replaced the top coal. The distance from where it was first noticed until it had usurped the place of the upper half of the coal-seam was about 450 feet.

Mr. DRON asked Mr. Clark whether he meant that the Ayr soft coal-seam corresponded with the ell coal of Lugar.

Mr. CLARK replied in the negative, it is not apparently represented on the Lugar section.

Mr. DRON said with regard to the whin in the New Cumnock district, it was common to get a whin dyke with the coal a little burned, reduced to a whitish ash on each side, and sometimes it was spread out for a distance of 350 feet, the whole of the coal-seam being destroyed by it. There was also a working within a few hundred feet of a volcanic neck, and the coal was as yet unaltered.

Mr. FISHER (Newton) said that in North Ayrshire he had seen, in the splint and main coal-seam workings, igneous rock within a few inches of marketable coal.

Mr. RUSSELL said that in the Kilmarnock district he had worked close up to the whin and taken out marketable coal.

Mr. J. T. Forgie (Bothwell) thought that Mr. Dron had correlated the coals in Lanarkshire and Ayrshire very accurately. He had taken some little trouble to compare the two sections, and was satisfied that the ell coal-seams of the two districts were the same. Regarding intrusive whins, he must say that he thought it was hardly likely that coal could remain unburned if the whinstone was intrusive. If the coal above the whinstone was unburned he thought it must have been deposited afterwards. He knew districts where there were large masses of intrusive whinstone and coal burned both above and below the whinstone. In the Kilsyth district, they had intrusive whinstone over the whole district. It varied in thickness from 2 feet to 250 feet, and in every case the coal-seams above and below were burned. It was burnt to a depth below almost equal to its thickness, and above to one and a half times its thickness. Mr. Clark had stated that it was unfortunate it should be there. In the Kilsyth district most people attributed to the presence of the whinstone the good quality of the coal for coking purposes. Some of it was very far from the whinstone, and where it was at its best it was 1,000 feet from whinstone. So it was difficult to see how the whinstone had anything to do with the coal. No doubt the coal had been affected. The intrusive whin did not maintain its position, in some places being 600 feet from the coking coal, and it did not always follow the same path. Whin dykes, as well as intrusive whin, occurred, and the coal started by being very slightly burned, and gradually got worse and worse till it took the shape of very fine dust and coke as if coked in an oven. They had driven a mine through it, and about 4 feet of the coal was soft, dry, and friable, it took the form of powder, and when thrown on the road, within twenty minutes, it got practically red hot through being exposed to the air. In some seams, for long distances, the whin did not intrude a single inch. In another it intruded itself for a long distance, but never increased the height from the roof to the pavement.

Mr. Faulds (Calderbank) said that some of the thin seams were under the intrusive trap, and sometimes the coal-seam was burned for 100 or 200 feet. To the west of Baillieston, they found the upper drumgray coal-seam inferior, but when it was slightly burned it became good steam coal.

Mr. Dron said that in the New Cumnock section a whin of about 30 feet in thickness occurred above the gas coal. He would like some of the members to say whether they thought that there was a connexion between the

whin and the presence of the gas coal. Mr. Forgie had misunderstood him, as he did not mean that there were cases where the intrusive whin left the coal-seam unburned, but where they were not much burned.

The discussion was then adjourned.

Mr. R. MARTIN read the following paper on the "Treatment of Timber for Use in Mines":—

THE TREATMENT OF TIMBER FOR USE IN MINES.

By ROBERT MARTIN.

The treatment of pit wood to render it durable and incombustible, though apparently a small matter, is of great importance for the safer working of mines, and deserving of the attention of mining engineers.

Falls of roof and sides are, as is well known, one of the most prolific sources of accidents in mines, and probably no one will be disposed to deny that many of these are due to decay or dry rot in the timbering. But in addition to loss of life and injury to person there is considerable expense at every colliery due to falls, such as stoppage of plant, clearing the rubbish from the roadways, and the replacing of timber. Systematic propping is good, and to be insisted upon, but the propping and securing of all main passages with timber as free as possible from decay is surely better.

Circular shafts lend themselves to lining with brick and cement, which are of such an enduring nature that anything else is scarcely ever thought of. Rectangular shafts, so common in Scotland, are almost universally lined with timber. It is very evident that this wooden lining should be so treated as to preserve it from decay or fire as long as the colliery is likely to be in use; the more so if the sides of the shaft are of soft materials. Those in charge of old shafts filled with winding-cages, pumps constantly in motion, haulage-ropes, pipes, etc., know the difficulty of carrying out thoroughly the repairs which may be absolutely necessary. The danger to all concerned from decayed timber in a shaft may be very great.

The writer knows a colliery, the pits of which were sunk through 60 feet of sand containing very little water. The barring was 6 inches thick of good pitch-pine, and was water-tight. The colliery had been in existence for about sixteen years. A portion of the area of one of the two pits was spaced off and used as the upcast shaft for both. The ventilation was produced by three furnaces and the furnace of a steam-boiler, all situated near the shaft in the various coal-seams being worked. After a long spell of wet weather, one forenoon without the least warning, at a depth of about 30 feet from the surface, the barring of the upcast shaft

suddenly gave way through decay; a large quantity of sand and water rushed into the pit, and falling down the shaft reversed the air-current. Fortunately the miners were idle on the day of the collapse, and the furnaces were burning low, or the consequences might have been much more serious.

Underground fires in mines and fires on the surface at the pit-mouth are of frequent occurrence. These are sudden, destructive, and frequently fatal. This is largely due to the use of ordinary timber in the engine-, pump-, and lamp-rooms underground, and in the erections which are situated near the pit-mouth on the surface. This timber is often so dry and sometimes so saturated with oil and grease, especially the floors, as to be readily inflammable; and an overturned lamp, a lighted match thrown carelessly down, or a spark from a passing locomotive may give rise in a few seconds to an uncontrollable mass of smoke and flame. It is not uncommon to see, in the midst of a lofty and extensive series of wooden erections at a pit-mouth, an open fire-lamp or brazier burning, the ashes and cinders from which fall on an iron plate resting close on the planks of the staging. It would seem to be the correct thing wherever machinery is placed, or stationary lights of any sort are fixed underground, and in surface-erections at the pit-mouth, that only iron, stone, concrete, or timber rendered practically incombustible should be allowed.

A method of treatment of timber known as the Henry Aitken method is in use at Niddrie collieries. In this process the idea is to soak the timber in hot or boiling water containing a strong solution of common salt and chloride of magnesium. The timber treated should be free of bark, well-seasoned, and thoroughly dry. For this purpose it is kept under cover for a time. The props that have been found most suitable are those free of bark and natural sap. These are mostly shipped from Sweden, and from several ports in Norway. The ordinary good class of battens and deals from Sweden can also be treated to great advantage.

The plant at Niddrie collieries consists of two malleable iron rectangular boilers made of ½ inch plate, each 19 feet long, 4 feet wide, and 3 feet deep, built into a brick-seating, with a furnace under each, a flue along the bottom and sides, and a chimney. There being no waste steam, the boilers are fired with dross coal, and kept as nearly at the boiling-point as possible. The tanks are covered with loose boards. The proportion of common salt to chloride of magnesium should be as 7 to 1, and there must always be unmelted salt at the tank-bottom. One tank is emptied and filled daily with props, crowns, sleepers, wooden bricks, wedges, ladders, and bratticing. This gives nearly two days' boiling for each

tank. The props, being mostly 6 inches in diameter, require boiling for this length of time, in order that they may be thoroughly penetrated by the salts. One day's boiling is quite sufficient for 4 inches prop-wood. Pitch-pine and larch require longer boiling than the softer woods. Each tank holds about 50 cwts. of all kinds of timber. About 15 tons of treated timber can be produced per week at a cost of :—

	£	s.	d.
Dross, 2 tons at 3s. per ton	0	6	0
Salt, 18 cwts. at 21s. 6d. per ton	0	19	7
Chloride of magnesium, 2½ cwts. at 3s. 7½d. per cwt.	0	9	1
Wages of one man attending	0	18	0
Total	£2	12	8

or, say, 8s. 6d. per ton. This adds about 1s. 5d. per 100 feet to the cost of 6 inches prop-wood. The royalty charges have to be added to this cost.

When the timber is removed from the boiler it is soft, and not in a condition for immediate use. It is dried by being put into a covered shed or stacked in the open air. A few days' exposure brings it back to nearly its original strength. When stacked on end, the props dry more rapidly than when placed horizontally.

The average life of ordinary prop-timber at Niddrie collieries is about ten months, thus involving frequent and costly renewals in brake-inclines, return-airways, and horse-roads. In some parts, where the decay is very rapid, timber treated as above described, has stood since the latter end of 1893, and it is still as fresh as when put in.

The temperature of the air varies from 68 degs. to 80 degs. Fahr., in some parts dry, in others moist. It is found that hutch-sleepers of home-grown fir, spruce, and, in fact, every kind of wood subject to decay, used in a pit, is made much more durable by this treatment. In the mine passages, salted timber is easily distinguished from other timber by its damp appearance.

No experience has been gained at Niddrie as to the behaviour of salted wood in case of fire ; happily there has been no occasion. As a precaution against fire, if salted wood were used for lining or flooring engine-rooms or pit-head erections, being always damp, it would not catch fire so readily or burn so fiercely as ordinary timber does.

The cost of the plant is about £100.

Mr. FISHER (Newton) asked whether the incidental charges over and above the mechanical process were included in the cost given?

Mr. MARTIN said that the man was not fully employed, but his whole wages were included in the cost.

Mr. J. B. ATKINSON asked whether Mr. Martin could give them an idea as to the non-inflammability of the salted timber.

Mr. MARTIN said that the only thing he could refer to was the case of a miner who hung to a treated post his coat and vest containing his tobacco pipe: they took fire, and the whole were burned to ashes scarcely making any impression on the treated prop on which they were hung.

Mr. DONALD (Cambuslang) said that it seemed somewhat surprising that one man was able to handle all the timber necessary in connexion with a large colliery, and dry it thoroughly at so low a cost.

Mr. MARTIN said that the quantity of timber handled was 15 tons, being that used in the horse-roads and return-airways.

Mr. FORGIE said that the special object was to make mine timber non-inflammable. Hitherto, it had always been found that such attempts caused it to become brittle, and it did not stand the weight so well as before, while, as regarded pit sleepers, the nails would not hold. At Messrs. Baird's collieries, ten years ago, they commenced to creosote the timber for underground purposes; and as regarded two pieces of timber in the return air-course, one of which was so treated and the other not, he saw the former a fortnight ago and it was as perfect as when put in ten years ago. The process had been discontinued, because there was a certain amount of danger connected with it. No doubt the timber was made more liable to take fire than in its natural condition. Then, when used as crowns, it was found to get quite brittle. He asked Mr. Martin if his process had the same effect on the timber and how he dipped it?

Mr. MARTIN said that one man did not seem to have any difficulty in filling the tank. They had no complaints from the miners as regarded the timber, and did not observe that it was any more easily broken than other timber. They tested a batten 7 feet long, 9 inches by 3 inches, for its breaking strain, and found that 45 cwts. broke it. They tried a salted one and it broke at 42 cwts. This difference might have been due to the timber itself.

Mr. WATSON (Cadzow colliery, Hamilton) said that with hutch-sleepers treated by this process they found the nails corroded easily, but since using galvanized nails there had been no complaints.

Mr. MENZIES (Blantyre) said that some two years ago they tried this system, but unfortunately he was not in a position to say much about it, for they had had to renew the timber before it was done. They gave up treating the sleepers because they would not hold the nails. He must say that in the preparation of the wood, he could not do so much work as Mr. Martin stated with one man. It took two men, and they were not dipping a quarter of the wood that they were using. He admitted that it was a good idea, but, unfortunately, it did not suit Auchinraith colliery, for there the wood was broken in a few months. At the same time there was a piece of timber which had been standing in their return air-course for seven years.

Mr. AITKEN remarked, as to the objection to the sleepers not holding nails, that he never heard before of their not holding.

Mr. MCVEY (Cadzow colliery, Hamilton) said that after using galvanized nails in the sleepers, they had no difficulty as regarded oxidation. With reference to the cost of salting the wood, they heated the tank with exhaust steam, and only used two cages per day, each containing about 2½ tons. Two men did the work. As to the cost, they did not reach Mr. Martin's figure. They simply used salt, and the cost did not amount to 1d. per cubic foot.

Mr. FERGUSON (Blairadam) wrote that the Aitken process had been in use at the Lochore and Capledrae collieries for upwards of six years, and during that time it has proved a great saving, not only in wages, renewing broken timber, but also in the price of wood used, which is now nearly all foreign timber. The treated wood had stood in the return airways for six years, and was quite sound. If this wood had not been treated it would have been replaced twice during the above period, even if it had been larch. No tree which had been treated had shown the slightest decay during the six years.

Mr. CARLOW (Leven) wrote that the Fife Coal Company began to use the Aitken process in January, 1893, and had continued to do so ever since. The following experiments have been made with the process:—Two pieces of ordinary Norway fir, 3½ inches in diameter and 3 feet long, both weighing 10 lbs. before being treated, were selected. One of the pieces was treated by the salt process, and the other was not. After being treated it weighed 12 lbs. Both were taken underground and placed in a return air-course, and after eleven months were examined and reweighed. The untreated timber then weighed only 5 lbs. whereas the treated one weighed 12 lbs., being exactly the same weight as when it was put in.

They were put back into the mine, and allowed to remain eleven months longer, and again weighed, with the result that the untreated timber weighed 6 lbs. and the treated timber weighed 11¾ lbs. They were again replaced in the mine, and after a total exposure of three years they were examined, and while the treated piece was sound the untreated one was decayed. Two pieces of similar timber, that is ordinary Norway fir, were tried at the same time, but placed in a different pit. The weight of each before treatment was 9½ lbs., and the weight of treated timber was 11 lbs. After being two years underground, the weight of the untreated prop was 6 lbs., and the weight of the treated prop was 9 lbs. After three years they were examined, and while the treated prop was quite sound the untreated prop was decayed. Besides these tests, observations were made on the treated timber put into main roads, alongside of other timber not treated, and the treated timber remained damp and fresh while the untreated crown-trees were dry and soft on the outside, showing that decay was in progress. The amount of salt that timber will absorb depends on the firmness of the wood and its dryness at the time of treatment. Norway fir absorbs from 15 to 50 per cent. of its weight, that is, it becomes 15 to 50 per cent. heavier after treatment, while larch crown-trees absorb only 10 per cent. The cost is about 1d. per cubic foot for salt, and ¼d. for labour, a total cost of about 1¼d. per cubic foot exclusive of royalty.

The discussion was adjourned.

The meeting was then closed.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

TRINIDAD ASPHALT.

Trinidad Asphalt. *By* OTTO LANG. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen, 1895, vol. xliii., pages 667-673, with figures in the text.*

The author refers first of all to the untenable hypothesis contained in Messrs. Wall and Sawkins' official report, that the asphalt-deposits were being perpetually re-stocked by the continuous transformation of wood into asphalt, and very justly points out that, if such an hypothesis were admissible, we ought to find extensive asphalt-deposits in all tropical countries. He then summarizes briefly the main points of the accounts furnished by Messrs. Anderson (1789), Nugent (1807), and Manross (1855), taking as the real basis of the paper under review the memoir written by Mr. S. F. Peckham, of Michigan University.* This observer's long experience of asphalt-deposits elsewhere, especially those of California, gives to his description additional authority and value.

On landing near La Brea (*brea* is the Spanish word for pitch), it is noticeable how the asphalt is in slow and continuous movement seawards, being in that and in other respects comparable to a glacier. As soon as a shaft is dug, it begins to fill up again with asphalt rising from the bottom, as well as pressing in from the sides. When the tropical jungle growing on the asphalt catches fire, the surface of the latter is coked into "iron pitch," being deprived of its volatile and hydrating constituents. This "iron pitch," which differs much in appearance from the original asphalt, and occurs only in comparatively small quantities, has to be carefully sorted out before shipping the asphalt or sending it to the boilers.

The area of the great lake is estimated at 99½ acres, but the luxuriance of the jungle-growth appears to stand in the way of absolutely exact measurements.

Judging from the earlier descriptions, the asphalt has become harder and more stable within the last 106 years. But so-called "blow-holes" occur on the edges of the lake, giving vent to fluid, lustrous black bitumen, and it may be from one of these that Mr. Nugent was enabled to "fill asphalt into tumblers" in the year 1807. The irregularity of the areas of asphalt, into which the lake is divided by fissures may be, in part, traced to the weight and pressure of the water acting against their sides; their surfaces are slightly domed, and the edges are sharply angular. The bitumen has been so permeated and swollen up by gases that, when fractured, it presents much the appearance of an over-ripe cheese. Gas is continually rising to the surface and finding its way out into the surrounding atmosphere; its volume is estimated to be between a third and a half of that of the asphalt lake.

The asphalt is believed by Mr. Peckham to be a result of the distillation, during Pliocene and post-Pliocene ages, of the Miocene lignites—at comparatively low temperatures. There was, no doubt, a kind of fermentation going on in the lignite

* *American Journal of Science*, July, 1895.

itself, and thermal waters containing a large percentage of silica played a considerable part in the process of distillation. The author, however, objects that tropical plants would not furnish sufficient resin to make asphalt, further that natural bitumen is not usually associated with lignite-deposits, and, lastly, that plant-remains could hardly be preserved unaltered while such a process of distillation was going on in their immediate vicinity.

Referring once more to Messrs. Wall and Sawkins' hypothesis, no wood has been found in Trinidad in process of conversion into asphalt; indeed, the people who work the deposits say that wood, so far from decomposing in the asphalt, comes out of it just as it went in. It is true that, in certain shafts, masses of organic matter (humus) occur, which, according to the workpeople, become in time part and parcel of the bitumen.

The commonly assumed distinction in Trinidad between land-asphalt and lake-asphalt is asserted to be a false one. A line of rails laid on palm-leaves, some of which are 25 feet in length, conveys carts for loading the asphalt to and fro on the lake. The use of timber sleepers and palm-faggots had to be abandoned, as in time they sank through the asphalt, and no cart may stop many hours in the same position without the risk of being engulphed. The line of rails describes a circle round the central group of islands, which are possibly fragments of a crater-edge floating on the asphalt. In depth the lake is an inverted cone, and is supposed to be the crater of an ancient mud-volcano. O. S. E.

COAL-FIELDS OF JAPAN.

Coal Supply of Japan. ANON.

The important question regarding the coal industry of Japan is whether the collieries of the country can continuously supply the increasing demand for coal. This problem can only be solved after comparing the demand with the supply, and a careful study of the mines themselves.

The following table shows the annual production of coal since 1888: –

Year.	Production Tons.
1888	2,022,968
1889	2,388,614
1890	2,608,284
1891	3,037,288
1892	3,175,670

The production of coal has increased annually, and the average of the last five years shows an increase of 285,675 tons.

The consumption of coal may be divided under two heads, viz., for home consumption and export, as follows: —

Year.	Export. Tons.	Inland Use. Tons.	Total. Tons.	Annual Increment. Tons.
1888 ...	975,290	7,085,704	2,060,994	—
1889 ...	1,053,822	1,163,289	2,217,111	156,117
1890 ...	1,214,572	1,430,252	2,644,824	427,713
1891 ...	1,239,821	1,583,803	2,823,624	178,800
1892 ...	1,299,351	—	—	—
Mean ...	—	—	2,436,638	254,210

The consumption is increasing, and the time when the inland demand will reach 3,000,000 tons annually is not far distant.

Although there are many coal-fields in Japan, those of Kiushiu and Hokkaido only are worthy of consideration, as a source from which to obtain a large supply. There is an anthracite coal-field in Honshiu, and a brown coal at Atsusa, in Nagato, the Shiramizu coal-field extending over Iwaki and Hitachi, the Aburato coal-field in Wuzeu, etc., are fully well known; but the use of anthracite is somewhat limited, while the other coals, being inferior in quality, can scarcely supply the demand of the neighbourhood.

The number of concessions for coal-mining is 1,434, extending over 110,834,148 tsubo (1 tsubo = 6 shaku square) in area, which amount to 550,000,000 tons of coal, if the average reserve of the coal-fields be estimated at a rate of 5 tons per tsubo. But this cannot be accurate, since the extension of the mining concessions does not represent the proper area of the coal-deposits.

Of the numerous coal-mines, there are only 49 which produce annually over 10,000 tons of coal; the total production of coal from these mines in 1891 amounted to 2,275,617 tons or 74 per cent. of the production, and in 1892 their output amounted to 2,509,055 tons or 79 per cent. of the production.

The following table contains the names of the collieries producing 30,000 tons or more of coal per annum :—

Collieries.	Provinces.	Production.	
		1891. Tons.	1892. Tons.
Miike	Chikugo	593,259	481,191
Takashima	Hizen	100,717	181,904
Horonai	Ishikari	144,038	134,689
Nakanoshima	Hizen	138,960	160,849
Namazuta	Chikuzen	87,169	125,624
Otsuji	Chikuzen	74,930	72,972
Sorachi	Ishikari	61,528	107,731
Akaike	Buzen	58,810	56,351
Arate	Chikuzen	57,292	51,601
Daijo	Chikuzen and Buzen	56,092	48,285
Shinniwa	Chikuzen	48,643	125,474
Minezi	Buzen	46,800	59,950
Shakanoo	Chikuzen	45,148	45,073
Ikushunbetsu	Ishikari	43,726	50,416
Dainouura	Chikuzen	36,096	50,472
Katsuno	Chikuzen	35,408	43,431
Ariho	Nagato	33,672	—
Takao	Chikuzen	30,393	38,684
Hashima	Hizen	30,201	51,213
Hoshii (Hokoku) ...	... ...	12,827	50,393
Sasanotaira	Iwaki	—	34,264

Of the mines in this table, Nakanoshima has stopped work this year, and Takashima has fallen in its productive power. Most of the coal-mines were started between 1887 and 1890, the period during which the so-called "coal-fever" prevailed in the country. All deposits of coal which promised profit have been opened since that time, while those which were hopeless of yielding any profit have been left unworked even up to the present.

In estimating the future supply of coal, the conditions of each coal-field must be examined separately. There are only two or three collieries where the coal-

reserves have been hitherto calculated. The coal reserve of other collieries should be estimated from their present condition and the nature of the deposit.

Kiushiu Coal-field.

1. *Miike Coal-field.*—The area of this field is very large, extending over more than 3,000 cho (9,000,000 tsubo). There are two workable coal-seams, 6 feet and 8 feet in thickness. The amount of coal-reserve in these beds is estimated at more than 150,000,000 tons, all beds which are situated within 1,500 feet below the surface being included. This is the largest coal-field in Japan, and the mining arrangements are efficient. The coal is, however, too bituminous, the sulphur it contains is remarkable, and makes it unfit for use in ironworks. The overlying strata are composed of gravels and sand, and the quantity of water percolating through the porous roof of the whole district is enormous. When the sinking of the drainage shaft at Katsutate, with pumping machinery, is completed, the drainage of this deposit will no longer be difficult. At present this colliery can produce 700,000 tons per year, but it is questionable whether it can continue this large production for many years.

2. *Takashima Coal-field.*—The coal-seams found in the islets situated at the entrance to Nagasaki Bay, *i.e.*, Takashima, Hashima, and Nakanoshima, are very thick and produce coal of the best quality. Their extent, however, is very limited. While Takashima has been exhausted except a portion of Hiakuma, Nakanoshima has been drowned by the sudden breaking in of the sea; and the mines worked at present are therefore Hashima and Hiakuma in Takashima only. The production of these two mines is about 100,000 tons per year, and this quantity will not continue for long.

3. *Hizen Coal-field.*—Except Takashima, there is scarcely a coal-field in Hizen promising any hope. The colliery in Matsushima, in spite of its reserve of over 5,000,000 tons of coal, has already been abandoned on account of flooding, although 200,000 yen had been expended in the works. At Karatsu, in the Matsu-ura country, there are two workable coal-seams, 3 feet and 8 feet in thickness. The seams are dislocated by many faults and broken up into small divisions, and only few mines are being worked. The Kishiyama and Mutabe are good mines in this district, and can together produce about 100,000 tons yearly. Takuhara colliery in the same district will also produce 50,000 tons. The collieries in Kineshima will considerably increase their output in future, although insignificant at present. Besides those mentioned, there are coal-fields in Higashimatsu-ura, Nishimatsu-ura, Kitamatsu-ura, Kineshima, Koshiro, Higashihiki, Nishihiki, etc., but almost all of them promise but little. About 30,000 tons of coal, produced in these collieries, is at present exported from Nagasaki by Chinese merchants as "mixed coal," to meet the demands of the total production of inland China, while the remaining portion of it is mostly utilized for salt-making and other industries.

4. *Amakusa Coal-fields.*—The coal-seam found in this island is 3 to 4 feet in thickness. The quality of the coal is very good, the extent is very limited, in consequence of which a larger production than at present can by no means be expected.

5. *Chikuho Coal-field.*—Chikuho coal-field, in the prefecture of Fukuoka, is extensive, and as the greatest part of it was reserved as the "coal-field for the navy" up to 1889, it is one of the most promising. According to the report of Mr. Suzuki, geologist to the Geological Survey, the total coal-reserve of this field may amount to 85,000,000 tons. Extracting therefore 1,500,000 tons annually it will be exhausted in fifty years. The principal beds of coal constituting this coal-field are as follows:—

One bed starting from the Wusui and Yamada districts in Kamagori embraces, westward, Takakuma, Wuruno, Takao, and other collieries, extends towards the north, and passes through Namazuta, Shekinao, Katsuno, Tsuruta, etc., and many collieries, in the Nishikawa district, till it reaches Noma in Ogagori. The conditions of the coal-seams are different in some districts. In Yamada and Wusui, the thickness of the coal-seam is about 8 feet, and the quality excellent. But one portion of the coal is frequently changed into the so-called *senseki* (a kind of dry coal which is probably produced from the ordinary coal by volcanic action). In consequence of inconvenient transportation the mines are not yet opened. In Takao, situated north-west of the latter, there is a coal-seam 5 feet in thickness. The coal is good in quality, and possesses the character of caking and making coke. Separated by a river from Takao there are the Tadakuma, Yamano, Arii, and Namaguta coal-fields side by side, while on the opposite side of the river there are Shakanoo, Katsuno, Sugemuta, Ono-ura, and many other collieries. The Namaguta coal-mine will annually produce some 100,000 tons, and the quality of coal is excellent. In the Tadakuma coal-mine there are two seams, 5 feet and 3 feet in thickness. The quality of the coal is not so uniform as at Namasuta, but a part of the 5 feet seam produces good coal. At present the annual production of this colliery is 20,000 to 30,000 tons. The coal-seam at Sakano is rather unpromising. In Katsuno, in Kurate, there are two workable seams, 5 feet and 3 feet. The quality of the coal is of medium class, and one part of the seam is changed into *senseki*, while another part is dislocated by faults. Both Sugemuta and Ono-ura possess two seams similar to those at Katsuno. The upper 3 feet seam produces good coal.

The second coal-seam starts at the north-west corner of Kama, close to Tagawa, and passing through many collieries such as Seita, Gotoku, Shitasakai, Naokata, Shinmiou, Wueki, Nagayama, etc., extends northward parallel to the bed first mentioned. Two seams, 3 feet and 5 feet, belonging to this series are workable, but the quality of the coal is of medium class, and becomes gradually inferior northward along the extension of the bed. Collieries which have been opened for many years on a noticeable scale are situated at Seita, Shitasakai, and Shinniwu. These collieries, however, will be unable to produce a larger amount in future than at present, except perhaps Shinniwu, which is working Wuyeki and Nakayama connectedly, and is therefore promising.

Parallel to this second bed, especially on the eastern side of the Onga river, is found the Onga coal-bed. This bed is composed of three seams. The first, 5 feet in thickness, extends through Congo, Kusubashi, and Kakibu, while two other seams, 3 feet and 2½ feet in thickness, extend through Kozuki, Nakama, Iwase, Yoshida, Takasu, Yamaga, etc. The coal from this bed is rather inferior in quality, and (except such as is produced in Atsuji) is principally consumed in salt-making. The coal from Otsuji colliery, though similarly inferior, is largely exported in consequence of its being produced in larger blocks.

The next is known as the Tagawa coal-bed. It begins at the village of Soyeda in Tagawa, from whence it extends towards the north, passing through Ihara, Maki, Kawasaki, Ikejiri, Gotoji, Ikari, Ida, Miyao, Kawara, Yugeta, Hoshii, Kanoda, etc. It contains two coal-seams, 8 feet and 4 feet. The quality of the coal from this bed is very good, and at the same time the thickness of the seams continues throughout the whole Chikuho coal-field. But part of the coal-bed situated south of the Hoshii colliery is mixed with volcanic rocks and is changed into *senseki*. In consequence of non-facilities for transportation this coal-bed is partly left unworked; work, however, has been in progress, though not on a large scale. The Hoshii colliery is said to be the most promising among all the collieries in the Tagawa country, as it possesses two so-called

chitimen seams, 8 feet and 4 feet. Although at present, in consequence of want of proper facilities for getting the coal, the output is not considerable, yet it would not be difficult to obtain an output of 100,000 tons of coal per year if the methods of working were improved.

At the Kanoda colliery, the neighbouring concession to Hoshii, the 8 feet seam is now worked, while the 4 feet seam, which is supposed to lie under the 8 feet seam, is as yet undiscovered. Without regard to the extension of the supposed seam, this colliery may be said to be a hopeful one, and a considerable output will be seen in future.

The Ida colliery, a very extensive concession in this district, has been opened both in the 8 feet and 4 feet seams, but the former seam was soon abandoned in consequence of the occurrence of volcanic dykes, *senseki*, faults, and other obstructions. The latter seam is now only being worked, and is of good quality. Even the 8 feet seam would be perhaps workable in some parts. No river suitable for transportation of materials is found in this district, and a large output is not possible until a road is opened.

The Akaike colliery contains a seam 5 feet in thickness, and the coal is of high grade. The preparatory works having been nearly finished, the output in the coming years will continue to be as great as it is at present.

Besides the collieries above mentioned, there are many mines in the same country, as Nakamineji, Kamatsuga-ura, Ikejiri, etc. Although they are now working the 8 feet and 4 feet seams, their extent is very limited, and work is on a small scale.

The Ikai colliery (the late "coal-field of the navy") situated on the eastern side of the Ida colliery, and Oto, Kawasaki, Maki, Shinjō, etc., all the latter being to the south of the Yasunaga-toge, have not yet been closely examined. Although some portion of the seam may be *senseki*, as doubtless the Tagawa coal-bed extends to this district, a large production may be expected.

In Kasuga, there are three coal-seams, especially one seam, 5 feet in thickness, which is worked on the east of Sasakuri, while the other two seams, 3 feet and 4 feet, are opened in the adjacent districts of Niihara. Altogether they produce annually some 100,000 tons. There are also small seams in Munekata and Kiku; but they are not worthy of especial attention, being of small extent.

In the island of Yayeyama, in the prefecture of Okinawa, a coal-seam, 4 feet in thickness, has been opened. The quality of coal is excellent. A few years ago, unfortunately, disease broke out among the miners, and work was abandoned.

Honshiu Coal-fields.

6. *Atsusa Coal-field, Nagato.*—This extends through the districts of Funaki, Takachiho, Atsunami, Suye, Yakebe, etc., but its area is limited. There are only two workable seams, 3½ feet and 2½ feet in thickness, and the coal is of inferior quality. Consequently, this coal is only used for salt-boiling along the coast of Seto-uchi, and cannot supply the general demand of the country.

7. *Kishiu Anthracite.*—The quality is moderate. There are two thin seams that are workable of 1 foot and 2 feet in thickness. Their area is small, and its use is restricted to lime and cement manufactories.

8. *Shiramigu Coal-field.*—This field stretches over a wide area along the sea-coast of Iwaki and Hitachi. The 6 feet bed is alone workable, and the coal, though inferior in quality, may be used for many industries. Little water is found in the mine, the hard solid rock forming the roof requires no timbering, and the cost of getting the coal is therefore very low. If a railway were constructed and transportation facilities increased, the yield from this colliery would be sufficient to satisfy the demand of the Kwantō districts.

9. *Aburato Coal-field.*—This is controlled by the Sado mine. Although the quality is of very low grade, it may be converted into coke when cleaned.

Hokkaido Coal-field.

10. *Ishikari Coal-field.*—Many parts of Hokkaido yield coal. According to the report of Mr. Lyman, an American geologist, who formerly explored the coal-fields of Hokkaido, it seems that every coal-field embraces a considerable stock of coal, but since that time geologists, having made more accurate surveys, have found that the coal-fields, except the Ishikari, do not contain so much as Mr. Lyman expected. As great irregularities prevail in the deposits of coal in Hokkaido, and the transportation facilities are few, the only source for the future supply of coal will be the Ishikari coal-field.

11. *Yubari Coal-field.*—There are two workable beds of good coal, measuring 14½ feet and 4 feet in thickness. The coal reserve above the water-level is calculated to be more than 6,000,000 tons. This is one of the best coal-fields in the country, and will easily yield 300,000 tons of coal per year.

12. *Horonai Coal-field.*—There are four workable seams of good coal, 3 to 4 feet in thickness. Although the colliery has been opened for the last few years, and more than 1,000,000 tons of coal have been taken out, yet the remaining reserve above the water-level is calculated at 3,000,000 tons, and the future output per year will be at least 70,000 to 80,000 tons.

13. *Sorachi Coal-field.*—This is divided into two separate concessions, Kami-wuta-wusunai and Shimowuta-wusunai. The quality of the coal is excellent, and fit for coking. There are four workable seams, 3 to 5 feet in thickness. Although this field has been worked during the last few years, yet the remaining reserve above the water-level is estimated at more than 5,700,000 tons. The seams are, however, interrupted by dislocations, and the production of small coal is considerable.

14. *Ikushinbetsu Coal-field.*—In this field, the seams in all respects closely resemble the Sorachi field, especially in the irregular dislocations which occur. The extension of the concession is limited. No large production can be expected from this mine in the future.

In addition to those mentioned above, some coal-fields in the vicinity of Iwanai, *i.e.*, Chinu, etc., are now worked, but their extent is small.

The result of the investigations hitherto made in Hokkaido, though not yet completed, show that there is no probability of finding a large stock of coal; and as there is no facility for transportation, the opening of any new colliery is almost hopeless.

Conclusions.

(1) If worked unsystematically, with the object of large production, as at present, some of the largest collieries will be exhausted in a few years.

(2) It is disadvantageous that a continuous coal-field is separated into small concessions, which are worked separately, each with small capital.

(3) Temporary working with inadequate capital on a good coal-field should be prohibited.

In the past, industries did not rely upon coal to obtain their motive power. The following table (except for steamers and locomotives) shows the steam and water-power in 1891.

	Manufactures. Horse-power.	Mining. Horse-power.	Total. Horse-power.
Steam	25,998 ...	11,559 ...	37,557
Water	3,060 ...	2,562 ...	5,623

M. W. B.

EASTERN COAL REGIONS OF KENTUCKY.

By GRAHAM MACFARLANE. *Engineering and Mining Journal [New York]*, 1895, *vol. lx., page* 345.

This coal-field covers about 11,000 square miles. On the east and south, it is bounded by Virginia and Tennessee; on the west, by an irregular line beginning at the Ohio river in Greenup County, and extending through Pulaski and Wayne to the Tennessee boundary-line.

The changes in the bedding are so great that no satisfactory identification of the coal-seams has yet been made, and the correlation of the Kentucky coals with those of other States in the Appalachian coal-field is also involved in a conflict of opinion. A first examination of the matter leads to much more satisfactory conclusions than can be gained after more thorough investigation; and the identifications of forty years ago of the various seams is now much doubted.

J. W.

COAL AND OTHER MINES OF OHIO.

ANON. *Engineering and Mining Journal [New York]*, 1895, *vol. lx., page* 148.

The production of coal in 1894 was 11,910,219 tons, a decrease of 2,917,878 tons as compared with 1893. This diminution has never been approached in the State's history. Of the total production of coal, 2,555,466 tons were mined by machinery, a gain of 2,392 tons as compared with 1893. There are thirty-six mines in the State equipped with machines, of which nineteen are worked by compressed air and sixteen by electricity.

There was one accident for each 46,343 tons of coal mined; 264,672 tons were mined to each life lost, and 102,674 tons for each serious accident. In all, 38 per cent. of the year's casualties were due to falls of roof; 15 per cent. to falls of coal; 23 per cent. to contact with the mine cars; 7½ per cent. to premature explosions of powder; and one fatal and four serious accidents were due to fire-damp.

The iron-ore production was confined to the three counties of Jackson, Lawrence, and Scioto, in which there were mined 53,043 tons, which is the lowest quantity of any year since the compilation of statistics. J. W.

STRUCTURE OF THE RICHMOND COAL-BASIN.

By E. J. SCHMITZ. *Transactions of the American Institute of Mining Engineers*, 1894, *vol. xxiv., pages* 397-408.

The Triassic coals of the Richmond basin comprise about 189 square miles, of which not more than 1,200 acres along the outcrops have been worked, although mining has been carried on for more than 100 years.

The unsatisfactory success and progress of the industry of this coal-field is due principally to the irregularity and faulted conditions of the coal and also to the indifference of the State Government, which leaves the development of the field entirely to private enterprise, instead of aiding it by systematical and practical geological investigations.

In the Clover Hill district, the following section is found:—

	Feet.
Top coal-seam	3 to 4½
Strata	10 ,, 30
Main coal-seam	7 ,, 20
Strata	40 ,, 50
Bottom coal-seam (reported)	4 ,, 6

The coals of the upper two seams are hard, bituminous coals of square cleavage and fracture, nearing splint in hardness, and showing coking qualities. The main seam and especially the bottom seam sometimes contain considerable quantities of pyrites. Another section gives the workable part of the main seam a thickness of 11 feet 8 inches, of which 10 feet 10 inches is coal.

The Triassic rocks and their coal-beds were probably deposited during the period of the construction of the Appalachian chain while the Azoic (granite) floor was affected by the upward and folding movements of this chain. Such movements would account for the irregular and pocket-like growth and deposition of the coal flora, varying for different seams, as well as for the area of each seam. This upward movement seems to have been limited to, or more pronounced at, certain zones; namely, these of the present squeezes or troubles, since the coal is regular to the east of the Garret squeeze. And as this squeeze has a strike regular and common with that of the Appalachian chain, we may be justified in supposing that this and similar fault-zones or ridges have been caused by the forces which raised the whole Appalachian chain, and represent smaller ridges or anticlinals of that chain. Moreover, as the forming of the Appalachian chain was not due to a sudden movement, but must have occupied a considerable geological time-interval after the Permo-Carboniferous age, we may assume that the Triassic measures of this basin were deposited upon the uneven floor of granite rocks during the later period of the construction of the Appalachian chain, and that this uneven floor was under the influence, and took some part in the movements, of that chain.

The secondary disturbances caused by plutonic action and represented by dyke-openings, dykes, coking of coal in the vicinity of the dykes, etc., must have taken place near, or after the end of, the Tertiary period, since Tertiary deposits have been removed from the surface at these dyke-openings.

The practical value of the field as a coal-producer depends on the coal-areas which can be opened and made accessible to the shafts and slopes of the mines, of which those nearer the centre of the basin will probably have the better chance.

The author refers to a paper on "The Mesozoic Formation in Virginia," by Mr. Oswald J. Heinrich, published sixteen years ago,* whose conclusions and observations are in some respects different from those of the author.

A. W. G.

COAL DISCOVERY IN GIPPSLAND, VICTORIA.

ANON. *Australian Mining Standard*, 1895, *vol. xi., page* 519.

At Wontaggi North, two really good coal-seams have been opened up. No. 1 is an outcrop on the bank of West's Creek, between Korumburra and Anderson's Inlet (Victoria). When discovered, it was rather weather-beaten and water-stained, but on sinking, proved a first-class seam of black coal, 3 feet 6 inches thick.

No. 2 seam is 3 feet 9 inches thick, and is a quarter of a mile south, and close to the creek. Levels have been taken, which will no doubt prove it to be a continuation of the seam now worked at the Outtrim colliery. It is considered that the best means for conveying the coal to market would be by a light railway across the plains to Anderson's Inlet, which is 8 miles distant; this railway could be constructed at about a quarter of the cost of a line from the north through mountainous country.

J. W.

* *Transactions of the American Institute of Mining Engineers*, vol. vi., page 227.

COAL-DUST RENDERED HARMLESS.

Unschädlichmachung des Kohlenstaubes. ANON. *Zeitschrift für das Berg-Hütten- und Salinen-wesen im Preussischen Staate*, 1894, *vol. xlii., page* 228.

An apparatus for laying coal-dust by means of water-spray was fixed up in the Hansa pit, in October, 1893. From the bottom of the 1,083 feet (330 metres) level, the water for the pressure-engine at the 2,178 feet (664 metres) level is led thither through a system of pipes 6 inches (150 millimetres) in diameter. At the pit-eye, at the 2,000 and 2,178 feet (610 and 664 metres) levels, there branch off from this main pipe-system pipes 3·15 inches (80 millimetres) in diameter running along the western cross-cuts of both levels as far as seam F. Along the floors of seams E and F, pipes 2 inches (50 millimetres) in diameter branch off again from these and run along up to the working-face. At each inclined plane and gallery 1 inch (25 millimetres) pipes branch off from the 2 inches ones, and from them again 0·6 inch (15 millimetres) pipes lead up to every separate working-place. At the face these smallest pipes are provided with a valve and an indiarubber hose, 10 to 16 feet (3 to 5 metres) in length. The pipes are of galvanized iron, and those of larger diameter have flanged joints; the smaller ones screw on to each other like gas-pipes; all are in lengths of from 10 to 13 feet.

The fact whether sufficient water for spraying purposes is present at the bottom of the 1,083 leet level is ascertained by means of a pressure-gauge (which should show at least 35 atmospheres) inserted in the system, connecting with the pressure-engine at the 2,178 feet level.

The mean radius covered by the spray from the above-mentioned hose, worked by hand, is 49 feet (15 metres). Moreover, at every 164 feet (50 metres) of piping, valves and socket-pieces are fixed, and on to these fit 65 feet lengths of indiarubber hose, so that portions of the workings outside the ordinary radius of the sprayers may be watered when needful.

The original cost of the plant was between £600 to £650. The monthly expenditure on upkeep is estimated at £20 to £25.

But against the very considerable advantages of this arrangement must be set sundry disadvantages, such as a certain disturbance of the strata—the floor, for instance, tends to swell and rise. This movement will, no doubt, entail additional expenditure on timbering, and the number of workmen employed on repairs will have to be increased. O. S. E.

REMOVAL OF COAL-DUST BY WATER-SPRAYING IN WESTPHALIAN MINES AND IN THOSE OF THE SAARBRUCK COAL-FIELD.

Das Beseitigen der Kohlenstaubbildung durch Wasserberieselung. *By* JAROSLAV JIČINSKY. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1894, *vol. xlii., pages* 617-618.

The water-spray system appears to have been adopted as a consequence of the explosions which occurred in the Hibernia pit (Westphalia) and at the Camphausen colliery (Saarbrück), both largely attributable to coal-dust.

In Westphalia, besides the Hibernia pit, those which may be mentioned as possessing a very extensive system of water-sprayers are the Consolidation pits, Nos. 1, 2, and 3. Here at the uppermost level is a water reservoir, consisting of a gallery walled with cement, always kept full of water supplied from the overlying marls or direct from bank. Gas-piping leads downward from this reservoir, branching off to the cross-cuts at each level, and thence to the various inclined planes and working-places. For spraying at the face, indiarubber hose is fixed to

valves opening at requisite intervals into the pipes. The length of the entire system is 68 miles (110 kilometres), the total number of workpeople being 3,600 (of whom 2,970 are at work below ground), and the monthly production of coal is 41,500 tons.

The monthly expenditure on watering in the three pits is as follows:—

	No. 1. £ s. d.	No. 2. £ s. d.	No. 3. £ s. d.	Totals. £ s. d.
Labour in the pit ... { Done by the hewers }		7 2 6	17 19 0	25 1 6
Material (pipes and hose)	3 14 10	24 4 4	23 2 6	51 1 8
Totals	3 14 10	31 6 10	41 1 6	76 3 2

At the Camphausen colliery (Saarbrück), the pumping-engine below ground forces the water up to the main airway, where two galleries walled with masonry serve as reservoirs. These are used alternately, as the clearing out of the slime would otherwise cause considerable delay. Mannesmann piping is used, 3¼ inches in diameter in the shaft, 2 inches in the cross-cuts, 1 inch in the inclined planes, and ½ inch at the working-places. About every 150 feet, valve-openings are fixed to the pipes, in such wise that 80 feet lengths of rubber hose being fitted to them the entire gallery can be watered. As the water-roses often become clogged, simple nozzles are now used, about ⅛ inch across. The work is attended to by boys in the drifts and cross-cuts where no hewing is done, and by the hewers themselves (without any additional remuneration) at the face. This method of watering was inaugurated in 1886, and the expenditure up to the end of June, 1894, amounted to £4,855 for materials and £4,145 for labour, or £9,000 in all. The length of piping is 113,400 feet, the annual extension about 17,000 feet, the annual cost of material £725, and of labour £705. O. S. E.

METHOD OF COUNTERACTING THE PRESSURE OF STRATA IN COAL-MINES.

Der Gebirgsdruck und seine Bekämpfung im Kohlenbergbaue. By — Georgi. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1895, *vol. xliii., page* 47.

Under very high pressure, even brittle coal assumes a certain degree of plasticity, and when, in the course of working, hollow spaces are left in such material, it gradually closes in on such spaces again by dint of the pressure of the strata. Such movements are most apt to occur where there is already disturbance of the strata, or a fissure or cleft. The rules followed in practical work do undoubtedly tend to obviate the mischief; but they cannot always be strictly adhered to, and therefore special means of combating it have to be devised.

Timber sets with loose packing were used for more than a year with great success. Three planks, slightly apart, are laid on the top backings of the timber, where a stouter partition is required to prevent the fall of stone. At the side-walls, behind the uprights two horizontal rows of round wooden bars are laid, and behind these again vertical planks are set. The bars or props are 6½ to 7¼ feet long, their vertical distance one from the other is 2¼ to 2½ feet, and they reach simply from one upright to the next. In each row they are laid alternately a little higher and a little lower, and they are long enough to amply cover the back of the upright. The planks are 3¼ to 3¾ feet long, and the space between them is such that between every two uprights there are only two planks. The space behind the planks is, so far as may be necessary, filled with stone packing. If the side-walls are not very friable the packing may be dispensed with.

The above-described arrangement allows the outward pressure of the measures enough "play." The inward curvature of the cross-bars shows how great is the pressure, and gives timely warning of the necessity of renewing the arrangement, which can easily be done.

But the timbering of the roof must not be renewed at the same time as that of the side-walls, and with very great pressure of roof the renewal cannot be managed at all. The same method is adapted to iron girders, but not to masonry walls.

O. S. E.

ANACONDA COPPER-MINES, UNITED STATES.

Report on the Anaconda Copper-mining Company. *By* HAMILTON SMITH. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., pages* 559 and 560.

The Anaconda is the largest copper-mining property in the world, and is situated in the State of Montana, most of the copper and silver mines being in or near the city of Butte.

The Anaconda and Syndicate group (eight mines in all) have been worked to a depth of 1,200 feet, and since 1880 have produced ore yielding very nearly 400,000 tons of fine copper, together with a large amount of silver and some gold. Until the late development of electrolytic refining, but little profit accrued from the precious metals. With depth, the copper-ore deposits increase rather than diminish; in one of the mines at a depth of 1,150 feet an entirely new ore-body has this year been discovered, the ore being of high grade and the deposit of large extent.

The reduction-works are situated at the town of Anaconda, about 20 miles from Butte, the ore being hauled over a railway controlled by the company.

The cost of producing copper is less than at any other of the large copper companies. This, the author says, is due to the recovery, at reasonable expense, of the silver and gold contained in the pig-copper by electrolytic refining.

For the year 1895, the silver production at Anaconda will probably be over 5,500,000 ounces fine, and over 22,000 ounces of fine gold. The Anaconda mine produces more silver than any company in the world, except the Broken Hill proprietary mines.

J. W.

ELECTRIC MINING PLANT.

(1) *The Essen Coal Company's Electric Mining Plant, near Pittsburg.* *By* TIMOTHY W. SPRAGUE. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., page* 174. *With* 4 *illustrations.*

A few miles from Pittsburg, at Hazletine, is the largest electric-power plant for coal-mining purposes in the United States, and one of the largest in the world. It is installed to operate two of the mines of the Essen Coal Company.

After a thorough investigation of coal-mining machinery-plants, the writer came to the conclusion that where trouble developed with such plants it was nearly always traceable to insufficient power. It was, therefore, decided in laying out the plant to allow an ample margin of initial power.

Steam is raised by four Russell tubular boilers, each 5 feet in diameter and 18 feet long, and containing 64 tubes, 3½ inches in diameter.

The engine-room contains three automatic Corliss engines with cylinders 17 inches in diameter by 2 feet stroke, running at a speed of 153 revolutions per minute. They are set on brick foundations and have 10 feet fly-wheels. With

the steam-pressure usually carried, 90 to 100 lbs. per square inch, these engines will develop something over 200 horse-power each. They drive three 150 kilowatt bi-polar generators of the independent mining type, wound for 275 volts, and running at 510 revolutions per minute; they are compound-wound and provided with self-oiling bearings, ventilated armatures, and other improvements.

Illustrations are given of the independent arc lamp; of the coal-seams; the chain coal-cutter; and of the 80 horse-power electric locomotive, with loaded trip.

The electric-power generated is used at present for coal under-cutting, haulage, and lighting. It is intended to run sixteen under-cutters; to use two 80 horse-power locomotives, one in each mine, for the main haulage work, mules being employed to do the gathering; and to light the tipples, power-house, and underground workings, as may be necessary.

The coal-cutter is driven by a 20 horse-power motor, wound for 220 to 250 volts, having but one field-coil. The machine is 2 feet high, 2 feet 4 inches wide, and 10 feet 5 inches long when closed. It cuts to a depth of 5 feet, making the cut 3½ feet deep and 3½ inches high. J. W.

(2) *Twelve-mile Transmission of Power by Electricity.* *By* THOMAS H. LEGGETT. *Transactions of the American Institute of Mining Engineers*, 1894, *vol. xxiv.*, *pages* 315-339.

A detailed description is given, with drawings, of the power plant erected for the Standard Consolidated Mining Company, at Bodie, California.

The water-power is obtained from a mountain-stream in Sierra Nevada, 12½ miles distant, which drives four 21 inches Pelton water-wheels under a pressure of 152 pounds per square inch. Each wheel is rated at 60 horse-power and travels at a speed of 860 to 870 revolutions per minute; the shaft is connected by an insulated rigid coupling to the armature of the generator. The wheels are regulated by a very ingenious Pelton differential water-governor.

The single-phase synchronous system is adopted and the generator is a 120 kilowatt constant-potential, 12 poles machine. The potential of the generator under full load is 3,530 volts, but at present it is operating with about 3,390 volts.

The wire is of No. 1 gauge, soft drawn, bare copper, weighing 252 lbs. per 1,000 feet, attached to glass insulators on Klein, leaden thread, iron pins.

The two wires are 3 feet 8 inches apart, and the poles of tamarack timber, 6 inches in diameter, are placed at intervals of 100 feet; the wires are about 17 feet above the ground, which is extremely rough and uneven.

It was found advisable to wrap the naked wires with ⅛ inch sheet-elastic at the insulators, to prevent leakage occasioned by snow and ice resting on the cross arms.

About 100 horse-power is transmitted and used for driving twenty 750 pounds stamps, amalgamating-pans, etc.

On testing the generator and motor they were found to give an efficiency of 95·5 and 93·9 per cent. respectively.

The final efficiency of the transmission from the water-wheel shaft to the motor-pulley driving the mill varied from 77·7 per cent., with 20 ampères of current, to 79·2 per cent., with 25 ampères.

Some difficulty was experienced through lightning and through discharges of static electricity, due to a gradual charging of the line from a highly charged atmosphere, during wind storms; but these are now to a great extent overcome.

The entire cost of the plant did not exceed £7,600, while its operation for one month alone saved £400. Before the erection of the plant the monthly fuel bill of the 20 stamps mill, crushing and amalgamating 50 tons of ore per day, would often amount to £400. A. W. G.

(3) *An Unique Electric Coal-cutting Plant.* *By* TIMOTHY W. SPRAGUE. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., page* 57. *With* 2 *illustrations.*

There is at the mines of the Davis Coal and Coke Company, in West Virginia, an exceedingly interesting portable plant which has been designed for the purpose of making practical demonstration, under all working conditions, in mines where neither electric nor power apparatus of any kind is installed, of the economy and other advantages of machine under-cutting. All the operator is required to furnish is a supply of water and coal, and room where the cutters may be placed at work.

The equipment consists of a box car, of the type used for furniture (with extra head-room), which is 40 feet long, 8 feet wide, and nearly 9 feet high, containing a complete power-plant and electric generator.

The boiler is of the water-tube type, specially designed, 50 inches in diameter, and rated at 40 horse-power at 100 lbs. steam pressure. The engine is high speed, with a cylinder 8½ inches in diameter by 9 inches stroke, and runs at 300 revolutions per minute. The electric generator is of 75 kilowatts, or about 100 horse-power capacity, and is of the alternating three-phase type. It is wound for 550 volts and is belted from the engine to run at 900 revolutions per minute.

The coal-cutter is of the chain type, and makes a cut 3 feet wide by 6 feet deep in about 3½ minutes, withdrawing in ½ minute. The height of the cut is 4½ inches. At the mine in West Virginia, the equipment is now showing a rate of cutting averaging over 200 lineal feet of face under-cut 6 feet deep per shift of 10 hours. Probably, the most important feature of the cutter is the three-phase type of motor, which refuses to do more work than it can properly be called upon to do. Where a direct-current motor machine would burn out or break, this new type will simply stop until the strain is relieved. J. W.

IGNITION BY DETONATION IN FIERY MINES.

Detonations-Zündung mit Rücksicht auf ihre Verwendung in Schlagwetter führenden Gruben. *By* MAJOR J. VON LAUER. *Oesterreichische Zeitschrift für Bery- und Hüttenwesen,* 1895, *vol. xliii., pages* 511-515, 528-531, *and Plate XV.*

The author sketches the history of the progress made in the manufacture of detonators since the introduction of dynamite in 1869, and sketches of some of the patterns used by various manufacturers are given in the plate which accompanies the paper. He then describes the system of testing detonating-caps introduced by Colonel Hess, and used by the Austrian military engineers. The undercurrent of thought which runs through the whole paper is that the main factor in successful shot-firing by means of such detonators is a sufficiently great initial impulse.

The author attributes cases, which he quotes, of burning away of the high explosive without detonation, to the feebleness of the initial explosive-wave produced by the detonators used, and not to any defect in the fuzes. He points out that the purpose of the fuze is to initiate the detonation of the detonator, but it has no part or share in the direct transmission of the explosive-wave to the explosive. Further, he draws attention to the fact that it has been customary in (Austrian) collieries to use for shot-firing the explosives dynamite No. 1, rhexite No. 2, and wetter-dynamit, which require detonators containing from 4·6 to 12 grains (0·3 to as much as 0·8 gramme) of fulminate of mercury, and, as

In practice only one class of friction-fuzes has been used, namely, those to which 4·6 grain detonators are attached, the frequency of incomplete detonation is no matter for surprise, at least in the case of rhexite No. 2 and wetter-dynamit. But the teaching of experience has been so far ignored that the blame has been laid upon the friction-fuze, and some collieries have, under this mistaken impression, stopped the use of it. In order to avoid the danger of fire-damp explosion arising in fiery mines from such shots as deflagrate without exploding, the author advises the strict observance of the following rules:—

(1) Explosives must be always detonated by means of sufficiently powerful detonators. Newly introduced explosives should be subjected to a preliminary test, with the view of ascertaining which number of detonator is suitable for use with them.

(2) The fulminating portion of the detonator must be properly rammed down (enclosed), for only such caps can be depended on as do not suffer diminution or leakage of the fulminate of mercury.

(3) If it be proposed to use a large number of detonators, these should be tested beforehand, so as to secure that they are all in perfect condition and of equal efficiency.

(4) Where feasible, detonators should be specially re-dried just before use.

(5) If ignition is to take place in a damp or wet medium, then at the point of junction with the friction-fuze, the detonator and fuze should be protected by a water-tight luting (some kind of paste).

The author considers that the above regulations are an indispensable complement to the precautionary measures already in force in fiery mines. O. S. E.

PERCUSSION-DETONATORS FOR FIERY MINES.

Percussions-zündung mit Rücksicht auf ihre Verwendung in Schlagwetter führenden Gruben. *By* J. VAN LAUER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1895, *vol. xliii.*, *pages* 693-698.

After reviewing the history of percussion-detonators for military mining, the author considers their employment for industrial purposes as a substitute for the English safety-fuze, and describes the forms introduced by several inventors, particularly that of Messrs. Toman and Tirman, and the improved Tirman detonator. He considers, however, that in point of reliability and security this class of detonators is inferior to friction-detonators, the number of miss-fires being greater and the employment of dynamite cartridges to fire the blown-out shots dangerous in the case of fiery mines. Friction-detonators are safer during transport, less liable to be jarred in tamping, and safer to handle. The fact that the cap is only fitted into the percussion-detonator at the time it is required for use is regarded as a retrograde procedure rather than an improvement, as the loose cap is more susceptible to damage by moisture or the shaking out of its charge, and the probability of miss-fires, incomplete explosions, and ignition of fire-damp is correspondingly augmented. In fact the only benefit from the separation accrues to the maker of the percussion-detonator, who incurs less expense by forwarding the non-dangerous portion of the apparatus by itself. In view of the manifold advantages of the friction-detonator, the question of a slightly higher first cost is hardly worth consideration. C. S.

THE PREVENTION OF FIRE-DAMP AND COAL-DUST EXPLOSIONS.

Zur Verhütung von Schlagwetter- und Kohlenstaub-Explosionen. By ROBERT LAMPRECHT. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1895, *vol. xliii., pages* 1-7, 95-98, 107-110.

The author, as the result of a tour of inspection and study in the Rossitz-Zbeschau and Ostrau-Karwin coal-fields, and of his experience in the South Hungarian colliery district, furnishes a detailed account of the methods now in force in the fiery mines of Austria-Hungary for preventing fire-damp and coal-dust explosions. His memoir is arranged under the following headings:—

Blasting.—One of the most dangerous, and nevertheless the most generally used, of igniters is the Bickford fuze—which is set alight by means of flint, steel, and tinder. It probably owes its popularity to the ease with which it can be ignited by any and every miner, and its comparatively low cost—each shot costing about ½d. The sparks from this fuze have been proved to ignite gaseous mixtures containing as little as 1¼ per cent. of methane. It gives off very offensive smoke, and premature ignitions and miss-fires are frequent. In several pits of the Ostrau-Karwin coal-field, Bickford fuze is only allowed for blasting in stone in the immediate neighbourhood of the shafts, and then only on express authorization being given to that effect. In some pits, indeed, its use is absolutely forbidden. Many South Hungarian collieries use guttapercha fuzes, as they are very little dearer than the fuzes commonly in use, and are far safer, because they give rise to very few sparks. The author did not meet with any of the numerou systems devised for mitigating the sparking of fuzes.

The Lauer friction-detonator is not widely used in the Ostrau coal-field, and the same remark applies to the Tirman percussion-detonator. Electric detonators, which have been hitherto made use of exceptionally in sinking shafts and in drifts, have of late (at the instance, mainly, of some of the mining authorities) been used for other work also. The author recites various objections to them, but points out that at one company's collieries in the Ostrau coal-field, electric detonators of British manufacture are used, in which the current produces too feeble a spark to ignite even fire-damp. When several electrically-ignited shots are fired at one time the single report often masks the miss-fires, and to this cause may be attributed some of the accidents which have happened in the South Hungarian collieries. Shot-firing by electricity is regarded as expensive, the detonator complete costing 2¼d., and the most usual type (No. 1) of the Nobel machine is priced at about £5 10s.

Of the various precautionary regulations as to shot-firing, the author regards as one of the most important the employment of officials whose sole duty it is to do the blasting work, and who have to test carefully the atmosphere of the working-place for fire-damp before firing a shot. This arrangement is in force at most collieries, but the author holds that it should be compulsorily enforced in all.

Explosives.—Ordinary blasting-powder is practically tabooed in the fiery mines, because to its use are attributed many fire-damp and coal-dust explosions. Compressed blasting-powder, largely used in the Rossitz coal-field, is handy and cheap, but it is even more dangerous in the presence of fire-damp.

Dynamite is of extremely common use in the fiery mines of Austria-Hungary. Water-stemming, probably on account of the excessive care necessary in its manipulation, has been adopted only here and there, and moss-stemming has found equally little favour.

Among the explosives based on the principle that, owing to the mixture with a salt, the vapour arising from the water of crystallization cools down the heated

gases, soda-wetter-dynamit is much in request in the Ostrau-Karwin district. But it is not universally so: this form of wetter-dynamit is costly, it cannot be stored for more than four weeks without losing much of its explosive power, and its shattering force is small. Moreover, the author observes that soda-crystals already begin to lose their water of crystallization before a temperature of 34 degs. C. (93 degs. Fahr.) is reached. Nevertheless, he regards it as the safest and most efficient of the so-called safety-explosives.

As regards the nitrate of ammonium explosives, experiments have been made and are now being continued under the auspices of the Fire-damp Commission sitting at Rossitz and Ostrau. The author remarks that all high explosives have this disadvantage that sometimes they do not explode at all, but deflagrate (burn away with a hot flame). Then, too, in all safety-explosives, as the blasting-power is increased, the degree of safety is lowered: the safer an explosive is, the less easily does it explode, and therefore the stronger must be the detonators used until they, too, practically assume the form of small cartridges of dangerously explosive material.

Safety-lamps.—The Wolf benzine lamp is mostly used in the collieries of the Ostrau-Karwin district and in the pits belonging to the Hungarian State Railway Company. It gives a very good light, can be kept cleaner than the ordinary oil-lamp, and consequently allows of a gauze of smaller mesh being used (a circumstance which makes it much safer). Thanks to the mechanism by means of which the miner may relight his lamp, even when locked, miners have over and over again been enabled to flee from the onrush of noxious gases. As a fire-damp indicator, the author considers the Wolf superior to the Mueseler lamp. He gives the following table of experiments conducted with the former lamp at the Wilhelm shaft of the Emperor Ferdinand Northern Railway Company, at Polnisch-Ostrau:—

No. of Experiment.	Percentage of Pit Gas.	Velocity of Air-current in Feet per Second.	Remarks.	Results.
1	7½	14⅛	Two steel-wire gauzes.	Lamp extinguished.
2	8½	32·8	Do.	Wire gauze melted. Glass broken.
3	8½	32·8	Brass rider $\frac{1}{15}$ inch thick between the lamp-reservoir and the glass chimney. One steel-wire gauze.	Do.
4	8	16·4	Do.	Extinguished.
5	8	16·4	Rider between glass chimney and gauze. One steel-wire gauze.	Do.
6	8½	32·8	Do.	Wire gauze glowing for 1 minute. Glass cracked. Lamp went on burning.
7	8	16·4	Aperture, with gauze, ⅛ inch in diameter. Aperture directed against the air-current. One wire gauze.	Glass broken.
8	5	16·4	Do.	After glow of 1 minute of the wire gauze, glass broken.

The average velocity of the air in the Ostrau pits is 14¾ to 16½ feet per second. The above results are reassuring, inasmuch as they show that the glass does not break until the wire-gauze has become red-hot, and the miner who is aware of the danger has, therefore, time to shield his lamp from the stream of gases. A Wolf lamp, specially manufactured for England, to withstand velocities higher than those customary in Austro-Hungarian collieries, was also tested and found to be absolutely safe in air-currents of the highest velocity.

The author admits, however, that in the hands of reckless workmen the benzine lamp may become extremely dangerous. The Roumanians employed in the collieries of the Banate swing the lamp in such a way that they get some of the benzine out of it, and, notwithstanding all regulations to the contrary, light their cigarettes with it. Then, too, where the strata being much dislocated, shot-firing is usually dispensed with, these fellows manage to ignite fuzes by spilling and spurting the benzine against the lamp-gauze, and sometimes—to make the ignition start off better—they stick dynamite to the wire gauze! Dismissals and punishments have not availed to eradicate the evil. In the very month following the Anina explosion, and in the very same district, three cases occurred of unauthorized opening of Wolf lamps.

Notwithstanding the author's apparent dislike of the Mueseler lamp, he points out that it has been used for many years in the Rossitz district, and no accident has so far been traced to it. The Wolf lamp, on the other hand, was tried there over and over again, but could not be used on account of the thick layer of coal-dust which settled all over the lamp.

The Pieler lamp, though an excellent gas-indicator, proved too dangerous for the collieries of the Banate, and it cannot well be entrusted to ordinary miners. The lamp fires with even as little as 1½ per cent. of fire-damp.

Electric Lighting.—Fixed installations have been put down in two collieries. In order to prevent ignition of mine gases by the breakage of incandescent lamps, glycerine is made to fill the space between the protecting glass and the lamp itself. As regards portable electric lamps, experiments on a large scale are being made by the Fire-damp Commission at Rossitz and Ostrau. One of the best appears to be the Bristöl lamp in use at the Karwin colliery: it is said to burn from eight to twelve hours with 2½ normal candle-power, but is often found by experiment to give out after four hours; the weight is 5½ lbs. The great drawback of the electric lamp is that it can, of course, give no indication of the state of the surrounding atmosphere. But the author regards its counterbalancing advantages as so numerous that he prophesies its extended use in the future, if it be supplemented by a good fire-damp indicator.

Air-tightness of Safety-lamps.—The testing of safety-lamps, etc., for air-tightness by means of currents of compressed air should be made compulsory in all fiery mines.

Standard Safety-lamps.—Neither the Austrian nor the Prussian Fire-damp Commission have thought fit to recommend a standard safety-lamp for fear of checking the invention of new lamps or the modification of existing forms. Nevertheless, the author points out that a period of stagnation seems to have set in, and that in view of the extreme variety of form and character of the several lamps in use, the question of setting up a standard lamp is ripe for further consideration. He holds that the Wolf benzine lamp, slightly modified, is the one which best fulfils all the requisite conditions.

Ventilation.—One of the essential preliminary conditions of a good system of ventilation is the early commencement of exploring work, so as to relieve as far as possible the coal-seams of gas before winning and pannel-working are in

all swing. The author commends in this respect the system of pillar-and-stall work adopted in most of the Austrian fiery mines. But this system cannot be pursued in the South Hungarian collieries, where the pressure of the strata is perhaps unparalleled in Europe; the extent of this pressure may be gauged by the enormous consumption of pit-props in the Anina-Steierdorf district, where 36 cubic feet of timber is required for every 10 tons of coal produced. The author describes the method adopted for splitting the air-currents, and discusses further the system of working the South Hungarian collieries. On account of the steep inclination of the seams, overhand stopeing with packing is much in favour.

Precautionary Measures against Coal-dust Explosions.—The Rossitz collieries, although not particularly fiery, are reckoned among the fiery mines by the authorities, on account of their easily inflammable coal-dust. The author witnessed a coal-dust explosion brought about in the experimental gallery at the Segengottes pit. The extremely fine powdery dust was strewed along the floor for about 33 feet and ignited with compressed blasting-powder. This produced a flame about 98 feet in length. He remarks that a dark red flame, a large amount of coke incrustation, and fumes of after-damp appear to be the characteristics distinguishing a coal-dust explosion pure and simple. All possible means of preventing such explosions have been tried, and tried in vain, at the Rossitz mines during many years past, and now no further attempt is made to guard against disaster by exceptional precautions. Watering by a fixed system and watering by portable apparatus both proved costly in the extreme, as well as dangerous, on account of the large quantity of water that had to be used, the damage done to the coal, etc. Steam and water, and hot water, proved equally unsatisfactory. It must be borne in mind that the coal-dust in these pits is of an entirely different character from that in the Westphalian and Saarbrück collieries where the watering system is successfully applied. The author made an experiment with coal-dust (no pit-gas being present), and, with a charge of 8 ounces (230 grammes) of blasting-powder, dust strewed over a length of 13 feet gave a flame 59 feet long. Watering is out of the question here, as the water-supply is so scanty that even the quantity necessary for the boilers has to be brought from great distances.

Measures to be Adopted in the Event of an Explosion.—The author points out that the special instructions posted up in most fiery mines are often impracticable, by reason of the very minuteness of their detail. What is really the best thing to be done depends upon the particular circumstances of each case. He points out further how necessary it is that not only the overmen, but every collier who goes down the pit, should have in his mind the plan of the larger spaces and of the galleries or drifts leading to neighbouring shafts.

The clothing of the miners has its importance from the point of view of burns. Experience shows that it is the unprotected portions of the body that suffer the most serious scorching from the flame of the explosion; next in order are those portions to which the clothing fits tightest, such as the wrists and the part between throat and breast. Woollen or fustian garments, impregnated with coal-dust, spread the flame and burn like tinder. The supply of fresh air ought, therefore, to be such that the miner need not work half naked, and he ought to wear clothes of a light, smooth-textured material which does not readily take up dust.

The author concludes with some remarks on rescue work, on the building of temporary dams, and on the flooding of mines for extinguishing fires.

Mr. Lamprecht's views with regard to shot-firing and safety-lamps in fiery-mines are in part controverted by the Saxon engineer, Mr. J. Treptow.* He

* *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1895, vol. xliii., page 93

considers that electric ignition, and the consequent sparking, is unattended with [illegible]n risk in atmospheres wherein the Pieler lamp indicates no fire-damp. He further[illegible]r points out that in Saxon mines shot-firing is forbidden so long as any fire-damp is [illegible]s shown by that lamp. Placed in careful hands, it need not be regarded as in any[illegible]y sense dangerous, and it is valued in all Saxon mines as a most sensitive fire-damp [illegible]p indicator. Then, as to the shaking of benzine out of the Wolf lamp, that he aver[illegible]s to be only possible when the reservoir contains more benzine than the wick can [illegible]n absorb; but this need not happen at all if the lamp be properly cleaned and [illegible]d properly filled. Unauthorized opening of the lamps has not been known to occur [illegible]r so far, at any rate in the Zwickau-Oberhohndorf districts of Saxony; the method [illegible]d of supervision is very strict, and a culprit could hardly escape discovery.

O. S. E.

EXPLOSION AT THE ANINA COLLIERY (SOUTHERN HUNGARY).

Ueber die am 20ten October, 1894, *am Ronnaschacht in Anina erfolgte Gruben[illegible]- katastrophe. By* A. ZSIGMONDY. *Oesterreichische Zeitschrift für Berg- und [illegible]d Hüttenwesen* 1895, *pages* 89-91, *and Plate III.*

On October 20th, 1894, at 4·30 a.m., an explosion took place in the first level [illegible]l of the Ronna shaft at the Anina colliery, belonging to the Austro-Hungarian State [illegible]e Railway Company. Thirty-nine persons were killed on the spot, and thirty-one [illegible]e seriously injured, nine of whom afterwards died. This was the greatest colliery [illegible] disaster so far known in Hungary.

From the Ronna shaft and from both the Thinnfeld shafts the northern portion [illegible] of the Anina-Steierdorf Liassic coal-field is worked. The main coal-seam (12 feet [illegible] thick) is, in the district where the explosion occurred, separated by 23 to 26 feet of strata from the top seam (5 feet thick). Both seams are very pure, and are dusty and fiery. On burning, the coal leaves 5 to 6 per cent. of incombustible residue.

The mine is ventilated by means of a Geisler fan, 11½ feet in diameter, erected at the Thinnfeld No. 2 shaft. At its normal speed of 55 revolutions per minute, it passes more than 46,600 cubic feet of air per minute (half of this amount is accounted for by the Ronna shaft), the water-gauge being 2·36 inches. This fan, as indeed all others in use in the Anina and Reschitza coal-field, is provided with an Ochwadt automatic water-gauge, which considerably facilitates the checking of the depression. Daily barometric observations are made at the mine.

The lights used in the pit are in part Mueseler safety-lamps with one gauze and chimney, and in part Thinnfeld safety-lamps, a modification of the Mueseler with one gauze and no chimney. It is intended to introduce the Wolf benzine lamps, which are in use at all the other collieries belonging to the company in the Anina and Reschitza coal-field. For precautionary reasons the use of the Pieler spirit-lamp as a fire-damp indicator has been dispensed with. The Wolf benzine lamp is perfectly adequate for that purpose, and it has this advantage in comparison with other safety-lamps, particularly after the occurrence of an explosion, that, though it be closed, the miner can relight it himself.

The explosion happened immediately before the replacing of the night-shift by the day-shift. A miner, disobeying the strict regulation that no blasting is to take place, unless permission be previously obtained, had, without authorization, fired a shot by means of tinder-fuze, flint, and steel. His body was discovered a few feet away from the shot-hole. The shot-hole was found partly intact, and a portion of the dynamite-charge still remained in it. There is every reason for assuming that the shot, whether fired prematurely or clumsily handled after

appearing to miss-fire, brought about a coal-dust explosion. It should be mentioned that the main seam is exceedingly dusty, but does not emit fire-damp suddenly or in large quantities. Moreover, so far as the top seam is concerned, there were no burns on the bodies found at the workings in it, and this is certain evidence that the fire-damp from the top seam had no share in the explosion.

The destruction of ventilating-brattices by the force of the explosion opened a shorter passage to the air in the Ronna shaft, and the water-gauge connected with the Geisler fan at the Thinnwald No. 2 shaft sank from 2·36 to 1·58 inches. The barometer was rising at the time of the disaster.

As a consequence of the explosion, a fire broke out in the Thinnfeld No. 8 level, and the damming off of the western portion of the pit between that level and No. 7 level was proceeded with two hours after the accident. Hardly had a temporary clay dam (5 feet thick) been erected than a second explosion occurred, but the dam did not give way. That part of the pit which was on fire was afterwards flooded with water by means of ¾ inch iron pipes, and, after extinction of the flames and lowering of the water-level, the remaining bodies of the victims were brought to day, that sad work being finished on December 21st, 1894.

A sample of gas, taken six weeks after the damming operations, from a pipe inserted in the clay dam at Thinnfeld level No. 7, yielded the following analysis: —Carbonic acid gas, 0·9 per cent.; oxygen, 0·4 per cent.; carbon monoxide, 0·5 per cent.; methane, 6·3 per cent.; and ethane, 3·2 per cent. The gases had an intensely disagreeable pungent odour, "not unlike that proceeding from dead bodies."

The miners are henceforth forbidden to touch any blasting-materials whatever, and these, as well as the conduct of all shot-firing operations in the pit, remain in the hands of officials specially appointed for that purpose. O. S. E.

RECOVERY OF THE KARWIN COLLIERY.

Gewältigungsarbeiten in dem Steinkohlenbergbaue zu Karwin. By JOHANN KOHOUT and JOHANN PILAR. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1895, *vol. xliii., pages* 311-314, 327-330, 342-345, 353-357, 364-368, 379-383, 394-399, and 409-411.

Shortly after the disaster at the Karwin colliery on June 14th, 1894, a Commission was appointed to institute and superintend the work of recovery which, in the interest of all parties concerned, it was desirable to expedite as much as possible.

After giving careful consideration to the various methods practicable, preference was finally accorded to that of direct ventilation of the shafts furthest removed from the seat of the explosion and fire, it being found that flooding the mine would occupy the greater part of two years and the subsequent removal of the water nearly a year longer with the appliances at hand. Accordingly, after pumping for over a week to clear the flooded No. 5 level, an exploring party entered the Tiefbau shaft, at the extremity of the western section of the mine, visited the Nos. 2, 3, 4, and 5 levels, and commenced the erection of stoppings. On the first and second days, the increase in the amount of carbon dioxide in the air of the shaft obliged the workers to withdraw, and then a further delay of a week was occasioned by a breakage of the pumps. The Franziska shaft was opened for the purpose of relieving the pressure of gas, but caution was exercised to prevent too much air—tending by gravity to displace the lighter gas—penetrating to the fire.

To this end stoppings were erected, the men working, when necessary, in 3 hours' shifts, and wearing Bremen respirators, fed with air under slight pressure. As the stoppings were insufficiently strong to prevent the air leaking through (the depression exceeding 1·20 inches)' it was found necessary to strengthen them with masonry, and by the end of three weeks about seventeen were completed, of cemented brickwork 12 to 24 inches thick, isolating the Tiefbau shaft, which was now in a condition for the resumption of coal-winning.

On July 22nd a quanity of vapour ascended through the ventilator of the Franziska shaft, and the next day the explorers noticed repeated sharp alternations in the air-current down in the levels, culminating in a sudden rush of after-damp from the No. 3 or No. 4 level, which indicated an extension of the fire through access of air. The men were obliged to leave the shaft on account of the smoke, and on arriving at bank began to close the pit-mouth and extinguish the engine fires, when four or five explosions occurred in the mine, blowing away the ventilator-caps of the Franziska and Tiefbau shafts and causing the miners—at work in the latter for the first time—to retire as quickly as possible. The result of these explosions was to delay the work of recovery, undoing the labour of six weeks in a few minutes.

Seeing the direct ventilation method thus unsuccessful, the Commission resolved to adopt compressed-air respirators, selecting the Bremen form of apparatus, supplied by air-compressors of the Brown and Stanek types. The air pumped at 75 pounds pressure into iron reservoirs, large enough to contain 1½ hours' supply, could be reduced by the valves employed down to an excess pressure of 3 pounds. Extra hand-pumps were provided, and the cage fitted with an air-reservoir for use in case of breakdown of the machinery or tubing, and extra branches at each level were affixed to the main air-trunk with the same object. The air-supply requisite for each man per minute was ascertained in practice to be 5 cubic feet (150 litres) or some fifteen times the amount actually necessary for respiration, the surplus being expended in ventilating and cooling the mask of the respirator. For lighting the men at their work Bristöl secondary electric lamps were used, and an electric system of signalling was installed to facilitate communication between the explorers and the bank.

Towards the end of August everything was ready for the resumption of work, but little progress was made at first, owing to the failure of an attempt to isolate the Franziska shaft by stopping the ends of several seams at the No. 3 level. Walling-up the way-ends and the levels succeeded better, and as soon as these stoppings were found to be effectual the shaft was ventilated by means of a steam exhauster and zinc air-pipes, to insert which the cage had to be removed and replaced by one lighter but still strong enough to carry a load of 600 bricks in two tubs. The pipes, down to a depth of about 600 feet, were single zinc pipes, 25¼ inches in diameter, with collar and socket-joints and three iron collars in each length to impart greater rigidity. Below this depth two pipes of sheet iron, each 12 inches in diameter, were used. For horizontal work and where weight is not a consideration, this metal is cheaper and better than zinc, which is easily damaged. Before being connected with the pipes, the exhauster had a capacity of 48,000 cubic feet of air per minute, and the completed apparatus drew at the No. 4 level 3,200 cubic feet per minute under 0·40 inch of depression, and 9,200 cubic feet under 3·54 inches of depression measured at the surface, the average working pressure being about 2 inches of water.

To counteract the depression behind the barriers, beyond which the work of recovery was proceeding, a kind of buffer space was created by the erection of double barriers with doors, the same means being adopted in the eastern section

of the pit for the opposite purpose, viz., to regulate the compression of the after-damp proceeding from the burning coal. One part of the work attended with some difficulty was the removal of water accumulated from the direction of the Tiefbau shaft and backed up, sometimes over 3 feet deep, by heaps of *débris*. To get rid of this water without allowing air to flow in through the water-channels, sliding shutters were fixed at the barriers and dropped into the channels, cut deeper at these points to form a water-seal. Most of the *débris* was removed from the pit and the remainder piled up in drifts and in vacant spaces.

The bodies when found were enveloped in cloths drenched with disinfectant (carbolic acid was first used, and was afterwards superseded by the non-poisonous lysol), nailed up in coffins and sent up to the surface for interment. The men engaged in their removal wore indiarubber gloves, and every precaution was taken, under the superintendence of a doctor, to avoid contagion. The dead bodies of horses were also disinfected and placed in zinc-lined wooden cases on wheels. To ventilate the space where dead horses were found, fresh stoppings were erected, and, after the old ones had been pulled down, a strong draught was induced by working the ventilator up to 3½ inches of depression.

On running off a considerable accumulation of water, collected behind stoppings in the No. 4 level, an increase in the amount of carbon dioxide, with a concurrent decrease of oxygen, and an alteration of pressure from 0·80 inch of depression to 0·40 inch of compression, was produced in the Tiefbau shaft, the after-damp from the burning section having flowed into the vacuum caused by the removal of the water. A number of tables showing the composition of the atmosphere in the shafts are given in the report, the conclusion drawn from the observations recorded being that whenever the atmospheric pressure diminished, the ratio of carbon dioxide to oxygen was increased and *vice versa*.

From the middle of September to the end of October further progress was made in the isolation of the Tiefbau and Franziska shafts in all directions where ventilation tests revealed the existence of connexion with the seat of the fire, and two explosion-proof stoppings were built, on the Nos. 2 and 3 levels, of solid cemented masonry, about 5 feet thick, with a convex face on the side nearest the fire, so that towards the middle of December the work in these two shafts was completed. Thereupon the ventilating pipes were removed, the large cage again placed in the shaft, and clearing up the recovered workings pushed on, until by the end of the year the resumption of coal-getting was practicable.

Meanwhile, the preliminary examination of the eastern shafts (Carl and Johann) had been undertaken and the cage in the latter found to be stuck fast at a depth of about 900 feet near the No. 6 level.

In the former shaft, work was now begun with the respirators, the procedure being in all respects similar to that in the western section. Directly the stoppings were erected, a considerable amount of gas-pressure developed in the burning portion of the pit, necessitating the boring of apertures through the explosion-proof barriers, and the provision of pipes to convey the gas to a safe distance above the suface. The proportion of marsh-gas in the galleries was very high, amounting to between 40 and 60 per cent., but the constant access of air through the barriers when opened for the passage of the workmen reduced this down to within the explosive limit, and great care was therefore exercised—by protecting the accumulator-lamps, searching the men for matches, etc.—to guard against another explosion. In the Carl shaft, the accidental breaking of a lamp caused an explosion, injuring 11 workmen, but fortunately the effects were only local.

It is mentioned that the electric lamps of English manufacture proved more reliable than those obtained from Vienna, the latter requiring to be re-charged at the end of 2, or at most 3, hours, instead of 6.

The result of the work so far has been to shut off the burning seams from both the eastern and western sections of the pit, and enable coal-getting to be resumed. Efforts will now be made to still further contract the fire area, but this work will be tedious, and it is stated that the disaster wrought by the June explosion will require years to remedy. C. S.

MINE EXPLOSIONS GENERATED BY GRAHAMITE DUST.

By WILLIAM GLENN. *Transactions of the American Institute of Mining Engineers*, 1894, *vol. xxiv., pages* 195-207.

The vein of grahamite is a straight and vertical fissure about 4 feet wide, which cuts downward across the horizontal strata of shales and sandstones forming the upper barren Coal-measures of West Virginia. Grahamite is a form of asphalt or mineral pitch. The method of working called "standing breasts" resembles the overhead stoping of the metal-miner and consists in starting a stope from a lower level and carrying it upwards to the level above; the miner stands on the material he has already broken down and works at that above his head. Ribs are left between the stopes and the material is run through a shoot into the level. The mine was absolutely dry and exceedingly dusty, moreover, the dust was of such an inflammable nature that it would often ignite at the naked lights of the loaders when filling the cars.

The first explosion was caused by the use of blasting-powder, which ignited the dust in one of the rooms, whence a sheet of flame travelled through the mine and on reaching the outer air and mixing with sufficient oxygen, it immediately exploded with tremendous force and covered everything around with a coating of coke.

No gas had been found in the mine, it was therefore assumed that the blast pulverized a great deal of the dry vein-matter, which immediately decomposed into coke and inflammable gas.

After the explosion, no more shots were fired in the vein matter, but blasting had to be resorted to in widening the side walls; this, however, was only done by the shot-firer, and when no one else was in the mine.

A second explosion of a similar character occurred two years afterwards, in which the shot-firer and 3 others who remained in the mine, contrary to orders, were killed.

The force of the explosion may be gathered from the fact that an oaken board was driven along one of the levels and hurled on to the hillside across a valley 500 feet wide. A mine car was driven 90 feet horizontally and broken to splinters, the cast-iron car-wheels being broken by impact against soft earth.

A. W. G.

EXPERIMENTS FOR DETERMINING THE REFRACTORINESS OF FIRECLAYS.

By H. O. HOFMAN and C. D. DEMOND. *Transactions of the American Institute of Mining Engineers*, 1894, *vol. xxiv., pages* 42-66.

The two methods of determining the fusibility or refractoriness of fireclays are the theoretical and the experimental. In the former, conclusions are drawn from the chemical composition; in the latter, from the changes which the clay undergoes when subjected to intense heat. The fire-resisting power of a clay, considered from a chemical point of view, depends, first, upon the character of the fluxing

constituents and their relation to alumina and silica, and, secondly, on the relation of the alumina and silica to one another.

The method adopted by Prof. Bischof in obtaining his refractory quotient, as also that of Prof. Seger are given in detail, and the author concludes the theoretical portion of the paper by pointing out that chemical analysis can only have an approximate value since clay is not a chemical compound, but an intimate mixture of several minerals; moreover, that analysis necessarily ignores the physical constituents, and therefore that it must be supplemented by actual experiment.

Experimental methods are either direct or indirect. The direct methods consist in heating cones, bricks or small fragments of the clay and noting the effect, whether complete fusion or fritting takes place, or whether the clay remains unaltered. The indirect methods consist in mixing the clay to be tested with fluxing or refractory substances, until it shows the same behaviour in the fire as a given standard clay. The amount of ingredients required to accomplish this will be the measure of the fire-resisting value.

The tests are made in clay crucibles, heated in a Sefström or Deville furnace, with coke or gas-carbon, to temperatures of from 1,500 to 1,775 degs. C.

Prof. Bischof, who originated these methods, toned down refractory clays by the use of finely pulverized quartz. Prof. Richters supplemented this method by the use of pure alumina to tone up a low-grade clay.

The disadvantages of these methods—namely, the nicety required in regulating the very high temperatures, the tendency of the reagent in the alumina method to act too powerfully, and the fact that the silica method is not always applicable—prompted Prof. Bischof to combine the two and use an intimate mixture of equal parts of pure silica and alumina. This does not soften at the highest temperatures, and as it is more refractory than the best known clay it will always tone up any clay to which it is added.

New Experiments.—Hitherto, experiments have always been carried on with extremely high temperatures and inside crucibles, so that the sample was excluded from view during the operation, and changes could only be observed by removing the crucible from the fire and allowing it to cool. This has led the writers (*a*) to construct a furnace in which the temperatures could be easily measured and controlled and the samples watched while the tests were being made, and taken out or exchanged with little or no delay; and (*b*) to devise a method of testing which did not require temperatures approximating to or surpassing the melting-point of platinum.

The furnace used is described in detail, with plans, etc. The standard of measurement consists in comparing the results with Seger cones, of which a series has been got up, measuring temperatures varying from 1,150 to 1,700 degs. C.: the difference between each cone in the series being calculated as 28·9 degs. C. The temperature indicated by the cone is reached when its apex has bent down to its base.

The method followed is based on the use of calcium carbonate as a flux. The amount of lime which it is necessary to add to a weighed quantity of clay to form a fusible compound at a certain elevated temperature will form the criterion of the refractory value of the clay. As lime is a very powerful flux, and would, therefore, have a very strong effect if added, even in small proportions, to a fireclay, it seemed advisable to try and weaken this effect by diluting with silica and using the mixture instead of the stronger, pure, calcium carbonate. The paper concludes with illustrations and tests of fireclays, kaolins, and brick-clays.

A. W. G.

DINAS FIREBRICKS.

Dinassteine. *By* E. SEGER and E. CRAMER. *Stahl und Eisen*, 1895, *vol. xv.*, *pages* 1084-1087, *with figures in the text.*

The authors lament the fact that, in consequence of certain industrial traditions, British-made firebricks are often preferred by the German user, to the detriment of the industries of his own country. The so-called Dinas firebricks are a case in point: the raw material, in the shape of highly siliceous quartzose rock, occurs in many districts in Germany, and there appears to be no valid reason why Germans should not make their own Dinas bricks. The requisite characteristics of these are that they should have a tough, compact texture, possess a high fusing-point, contain a large proportion of silica, and retain at all temperatures a practically constant volume. The following methods of testing were applied by the authors:—

(1) For toughness, by striking with the hammer till the brick rings; according to the sound produced, so is the quality of the material estimated.

(2) For high-fusing point, by heating small splinters in the Deville furnace. This is practically a hollow cylinder of highly refractory material, with an iron jacket. It is 13¾ inches in height, 4 inches in diameter inside, and has walls 2¼ inches thick. Temperatures are gauged by means of Prof. Seger's normal fusion-cones: these are tetrahedra, made up of mixtures of clay and sand or glazes, which have various fusing-points. A list of 58 of these cones is given, with their chemical compositions and temperatures of fusion, the latter ranging from 710 degs C. (1,310 degs. Fahr.), dark red heat, to 2,180 degs. C. (3,956 degs. Fahr.), at which point clay-slate fuses. When their fusing-points are being determined or tested, the cones may be conveniently placed in the Heintz suspended cupels, of which figures are given. In testing the Dinas brick, the splinters are placed, alternately with the test-cones, in a layer of very fine kaolin-and-alumina slime, and gently pressed down into it, at the bottom of a fireclay crucible. The latter is then placed on a tripod standing over the hole in the iron plate which forms the floor of the Deville furnace. The bellows communicating with the furnace are thereupon set to work, and the latter is fired, at first with charcoal, then with retort-graphite.

(3) For constancy of volume, Prof. E. Cramer's method of measurement is used. This is based on the axiom that with increase or decrease of volume is intimately connected a fall or rise of specific gravity. If, therefore, the specific gravity of the firebrick be determined before and after firing, the results will show by how much the volume has increased or decreased. The authors work out numerically a sample-test to show how the method is applied.

Altogether, five varieties of Dinas firebricks were tested, two of which were of British origin, two were manufactured at Eschweiler, and one at Homberg. Chemical analyses gave the following results:—

	Silica.	Alumina and Ferric Oxide.	Lime.
British No. 1 ...	97·40	1·49	1·11
,, No. 2 ...	96·80	2·23	0·97
Homberg	95·40	1·40	3·20
Eschweiler No. 1...	96·24	2·36	1·40
,, No. 2...	96·54	2·03	1·43

All five fused at temperatures between 2,120 degs. and 2,150 degs. C. (3,848 degs. and 3,902 degs. Fahr.); no difference could be detected in this respect. But in the matter of constancy of volume it is shown that the German firebricks are superior to the British. O. S. E.

MEASURING THE PRESSURE OF FIRE-DAMP IN THE LIEVIN MINES.

Note sur quelques Expériences faites au Siège No. 1 des Mines de Liévin pour Mesurer la Pression du Grisou dans la Houille. *By* A. SIMON. *Annales des Mines*, 1895, *series ix., vol. viii., pages* 218-231.

The experiments herein recorded were performed by making bore-holes of about 2¼ inches diameter into the substance of the coal to various depths, and then inserting to within about 8 inches of the bottom of each a flexible copper tube, connected with a Bourdon pressure-gauge or a gas-meter. The space between the copper tube and the walls of the boring was tamped with clay resting on an iron ring brazed on to the copper tube and carrying one or more rings of caoutchouc. This tamping proved staunch, but was difficult to remove at will, when, for example, it was desired to deepen the bore-holes.

All the seams in the No. 1 pit at the Liévin colliery being about equally gassy, the choice of locality was unimportant, except as regards relation to the workings. It was decided to make one set of investigations in a portion still unworked, where the coal would be solid, and another series in a part of the workings where the operation of coal-getting would have fissured and loosened the strata.

For the first series the Frédéric seam, at a depth of 1,560 feet was chosen, as there were no workings in this seam, or in the superior and inferior beds, for a distance of 800 feet, and the coal was therefore solid and but slightly penetrable by gas. The results of observations made in six bore-holes at different depths (from 30 to 40 feet) indicate that the pressure of the gas increases with the depth to which the boring is tamped, decreasing, as the tamping recedes, in proportion to the permeability of the coal stratum. In the present instance this was but slight, the coal being very compact. The yield of gas is, at any stated pressure, proportional to the free surface at the bottom of the bore-hole. The daily readings of the pressure-gauges during three months showed no sensible diminution of pressure. After two years (the bore-holes having been made in 1893) the average decrease of pressure was about 24 pounds per square inch (having fallen from 59 to 35 pounds), thus showing how the seam is bled by leakage of gas into the gallery. A certain time (about 5 or 6 days, or even less), is required for the pressure in new bore-holes to attain its maximum, but where the hole is left open for some days the maximum pressure is regained very slowly.

On measuring the delivery of gas, by means of a meter, it was found that 7½ cubic feet came off during the first 20 seconds, falling afterwards to 0·3 cubic foot per hour, the normal yield being throughout very feeble, averaging only 0·2 cubic foot an hour.

An examination of the shale forming the cover of the Frédéric seam resulted in the detection of merely slight quantities of gas.

In the Alfred seam, which is deeper than the other, a site was chosen where no workings, other than those in the seam itself, were in progress. This ensured that any disturbance or dislocation of the coal was only due to local causes. Here the diminution of pressure was more rapid, falling nearly 29 pounds in three months, by reason of the removal of the coal from the pillar in which the holes were bored. The yield of gas per hour was greater than in the Frédéric seam, averaging 0·7 cubic foot, and this from a smaller surface than in the last-named seam. So far from decreasing, in time the delivery rose, a circumstance probably due to the increased surface of liberation produced by the dislocation of the coal in the course of the mining operations concurrently carried on.

The author considers, in view of the experience now gained, that galleries and roadways, as well as bore-holes into the coal, do not have much effect in draining out

the gas, and that a more efficient way would be to increase the permeability of the coal by enlarging the faces of the stalls, so that the shocks produced by the pick or other mining instrument, would open up fissures in the interior of the mass of coal and facilitate the escape of gas. A similar effect is produced by working a higher or lower seam, and by the Bességes method, which consists in shattering the encasing rocks by blasting the front and wall of the seam. C. S.

TESTING OF UPCAST AIR-CURRENTS IN THE SAARE COAL-FIELD

Untersuchung der ausziehenden Wetterströme auf den Grubengas-gehalt. Abstract from *Zeitschrift für das Berg-, Hütten-, und Salinen-wesen im preussischen Staat*, 1894, *vol. xlii., pages* 222 *and* 223.

The following table shows the results of the investigations conducted during the year 1892 as to the amount of marsh gas present in the upcast air-currents of the collieries of the Saare basin: —

Name of Colliery.	Production (Annual).	Volume of Fire-damp (CH_4.)		
		Per 24 Hours.	Per Annum.	Per Ton of Coal Produced.
	Tons.	Cubic Metres.	Cubic Metres.	Cubic Metres.
Altenwald	383,184	4,194	1,530,810	3·995
Burbachstollen ...	136,846	6,254	2,282,710	16·680
Camphausen	194,242	14,589	5,324,985	27·414
Dechen	396,670	6,825	2,491,125	6·280
Dudweiler	455,836	14,479	5,284,835	11·594
Friedrichsthal ...	244,501	2,565	936,225	3·829
Geislautern	43,246	3,020	1,102,300	25·489
Gerhard	223,304	21,899	7,993,135	35·795
Heinitz	621,663	5,985	2,184,525	3·514
Itzenplitz	275,823	428	156,220	0·569
Jägersfreude	30,811	1,294	472,310	15·324
Kohlwald	327,452	4,085	1,491,025	4·554
König	395,516	9,914	3,618,610	9·149
Kreuzgräben	151,072	10,807	3,944,555	26·111
Lampennest	197,503	1,378	502,970	2·547
Maybach	266,206	9,281	3,387,565	12·725
Püttlingen	362,951	5,724	2,089,260	5·756
Reden	405,502	20,759	7,577,035	18·686
Schwalbach	372,199	2,553	931,845	2·504
Serlo	100,618	15,632	5,705,680	56·705
Sulzbach	212,607	2,350	857,750	4·034
Von der Heydt ...	302,327	4,444	1,622,060	5·365
Wellesweiler	23,434	1,688	616,120	26·291
Totals ...	6,258,890*	170,149*	62,104,385*	9·923*

* The figures add to 6,123,513 tons, 170,147 cubic metres, 62,103,655 cubic metres, and 10·141 cubic metres respectively.

Similar tables had been drawn up for the years 1890 and 1891, and on comparing them with the above it is seen that the total volume of methane poured forth annually in the upcast air-currents varies very slightly. Thus, for 1890 the figures were 63,116,530 cubic metres; for 1891, 63,215,445 cubic metres; and for 1892, 62,103,685 cubic metres. M. W. B. and O. S. E.

FLAGSTONE QUARRIES AT BANDERA, KANSAS.

By DAVID P. JONES. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., pages* 299-300, *with* 10 *figures.*

The deposits of natural flagstone, so far discovered and worked in the United States, are three in number. The North River bluestone of Eastern New York and Pennsylvania, the red flagstone of Colorado (generally called Fort Collins or Lyons stone), and the Kansas flagstone (commercially known as Fort Scott and Bandera stone).

The largest workable beds of this kind of stone in the United States are the deposits in Eastern Kansas. Though they spread over a smaller superficial area than the North River bluestone the beds or layers are deeper. In general, they can be quarried easily, and at a low cost, while the facilities for drainage are good. They are usually free from seams, so that stones of large size can easily be quarried.

The author's article is four columns in length, a detailed description, with costs, etc., of working, being given The figures illustrate the tools and appliances used, and there are two ink-photographs of the Bandera quarries in operation. J. W.

THE OCCURRENCE OF GOLD IN SANDSTONE AND SHALE.

Preliminary Note on the Occurrence of Gold in the Hawkesbury Rocks about Sydney. By A. LIVERSIDGE. *Journal and Proceedings of the Royal Society of New South Wales*, 1894, *vol. xxviii., pages* 185-188.

The Hawkesbury Sandstone and Waianamatta Shale are derived from older, and in all probability gold-bearing, rocks ; hence it was not unreasonable to expect to find gold in them, especially as gold has been detected in the Carboniferous Limestone and other rocks in England.

Gold has been found in the Coal-measure conglomerates of New South Wales, the presence of the gold is natural, these conglomerates being simply old gravels and analogous to later cements and similar gold-bearing deposits ; the Hawkesbury Sandstone is also analogous to a gold-bearing sea-beach.

The following table contains the results of experiments :—

No.	Hawkesbury Sandstone.	By Fusion with Red Lead.	By Cyanide of Potassium.
1	Building-stone	... None	... Not treated.
2	,, ,, ...	... ,, ...	... ,,
3	,, ,, ...	... Not assayed ...	... 35·84 grains per ton.
4	,, ,, ...	... Trace	... 8·96 ,, ,,
5	Pyrmont stone	... 14 grains per ton	... 12·32 ,, ,,
6	,, ,, ...	... None	... 2·24 ,, ,,
7	,, ,, reddish ...	... ,, ...	... Not treated.
8	,, ,, ...	... 7 grains per ton	... ,,
9	,, ,, ...	... 18 ,, ,,	... ,,
10	,, ,, soft and micaceous...	None	... 2·24 grains per ton.

Samples of the Wainamatta Shale were taken from the Sydney University grounds. A light coloured shale did not yield any gold, but a deep red shale yielded 2 dwts. 23·8 grains per ton. A nodule of hard ferruginous shale, practically hæmatite, yielded 3 dwts. 13 grains per ton. M. W. B.

GOLD AND SILVER—THEIR PRODUCTION, USES, AND LOGICAL RATIO.

By RICHARD P. ROTHWELL. *Engineering and Mining Journal [New York]*, 1895, *vol. lx., pages* 76-78 *and* 100-102, *with* 3 *diagrams.*

The author deals with his subject under the following three headings:—The actual and relative production of gold and silver; the cost of production of these two metals; and the supply of the precious metals for use in money.

Diagrams are given showing the monthly production and values of gold and silver in the United States, 1893-1894, and the fluctuations in production and value-ratios of gold and silver since 1492.

Statistics are also given of the world's production of gold and silver since the discovery of America in 1492.

From the evidence quoted, the author draws the following conclusions:—The manner of occurrence of gold and silver in nature precludes the possibility of their cheap production in large quantity. The cost of production of each will, in the great majority of cases, always approach very nearly to its market value over a series of years, and a large amount of each metal, especially of gold, will always be produced at an actual loss. Since profits in mining are, roughly, in inverse proportion to the unit value of the metal produced, and losses directly proportioned to this, the natural tendency from this cause is for gold waves to be shorter in duration than silver waves, as, indeed, the statistics show they have been. As gold or silver appreciates in value, more of each metal will be used industrially, and as they depreciate, less will be so used—contrary to the rule with metals which are in demand for their physical properties alone. J. W.

THE ORE-DEPOSITS OF CRIPPLE CREEK, COLORADO.

By FRANCIS T. FREELAND. *The Colliery Engineer*, 1895, *vol. xvi., page* 53.

The northern parts of the above district, *i.e.*, the Tenderfoot, Gold, Globe, Iron-clad and Bull hills, consist of andesite and andesitic breccia, bounded on the east, north, and west by granite and gneiss.

Many of the hills are capped by phonolite flows. Dykes of this last-named rock are common, and, among the less frequent eruptive rocks, basalt and diorite have been found.

The valuable metals contained in the ores are gold and silver; probably about ¾ oz. of silver is mined for each ounce of gold. Some of the gold is free; but at moderate depths the tellurides appear. While some of the ore gives very rich returns, the average product of the district runs about 3 ounces. This is to be considered a very high average grade considering the large tonnage. The principal associated mineral is quartz, both crystallized and massive. Some of the dull brown quartz is very rich, while the opaque white and blue-black quartz are poor in gold.

Among the deeper mines of the district are the Isabella, Victor, Anaconda, Moose, Elkton, Anna Lee, Independence, and Portland. The deepest workings of these mines show that the average vein is as profitable below as nearer the surface.

Cripple Creek is very well provided with facilities for the transportation and reduction of gold ore. The higher-grade rock is sold to lead-smelters at Denver and Pueblo; the medium grade is sold to two chlorination-works at Gillette and Lawrence and to two cyanide plants at Florence and Lawrence; while the low-

rade surface ores are worked up in the local custom stamp-mills by amalgama-on and concentration with a fair degree of success. Transportation is provided y two railways and good waggon-roads in every direction.

In the course of a few years, Cripple Creek has been changed from a peaceful ittle range to a busy mining centre, with a population of 12,000.

An output of over £60,000 from one mine in one month and over £1,600,000 in old in a year indicate the cause of this great transformation. J. W.

GOLD-MINING AT CRIPPLE CREEK, COLORADO, U.S.A.

ANON. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., pages* 321-322.

During the past six months, April to September, of the present year, there ave been many new discoveries in the above district; but nearly all have been f low-grade ore, containing not more than 1½ ounces of gold per ton, which annot be profitably mined and shipped to the smelters.

In not a few cases, however, wide, strong veins have been found, from which he ore can be mined at moderate cost; and, as the local reduction-works are ffering low rates, an increased output of ore from the district in point of tonnage rill result.

Present indications, therefore, go to show that Cripple Creek will become a arge producer of low-grade ore, which it has not been hitherto.

The summer now ending has not been, on the whole, a prosperous one for the listrict, owing chiefly to the long rainy season, which checked prospecting nterprises and the operations of small mines carried on in the open. The produc-ion of the larger mines has been checked by inability to ship their ores, the roads eing so miry as to be impassable by heavy waggons. Finally, the Florence and Cripple Creek Railway, by which coal is chiefly brought, was completely washed out for 12 miles or so in July, and over a month elapsed before trains could run gain. J. W.

MINING IN GUATEMALA.

ANON. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., page* 566.

The mineral products of this Central American Republic are gold, silver, iron, copper, lead, marble, gypsum, sulphur, bituminous coal, and salt. The principal now being explored are the gold-mines on the Motagua river, department of Izamal and Baja Verapaz; the silver-mines at Mataquescuintla, and at Alotepeque; the salt deposits of Nueve Cerros and of Chiguimulilla. J. W.

KALGOORLIE GOLD-MINES, WEST AUSTRALIA.

ANON. *Australian Mining Standard*, 1895, *vol. xi., page* 509.

An immense lode-formation has been discovered 2½ miles south-west of Great Boulder, at Kalgoorlie, in the Coolgardie district. The formation is similar to that in the Boulder properties, and carries gold right to the surface. The first assay made showed 40 ounces of gold per ton; but to check this result, three more samples were taken, giving 12, 15, and 100 ounces gold per ton. The gold is spongy and without metallic lustre. J. W.

THE CHLORINATION PROCESS.

(1) *An Improved* 10 *tons Chlorination Barrel. By* JOHN E. ROTHWELL. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., page* 370, *with drawings.*

This recent appliance was devised principally for use in the chlorination process, and is, therefore, lead-lined; but the general construction is adapted to the treatment of ores by any of the other processes which require the ore to be agitated in connexion with a chemical solvent. Where cyanide is used, the leaden lining would be omitted and the joints of the shell well caulked to prevent leakage.

The barrel is 15 feet in length by 5 feet 2 inches in inside diameter; the shell is of ⅜ inch steel-plates, two sheets of 90 inches width being required. The leaden lining, when the barrel is to be used for chlorination, is of 18 lbs. chemical sheet-lead. The advantages to be gained by a large barrel of these dimensions are said to be:--in first cost, it is much cheaper than two 5 tons machines would be; it is just as efficient and as easy to work as the two smaller barrels would be; and the space required for its erection is very little more than that required for one 5 tons machine.

There is also said to be a saving in chemicals used and in quantity of water required to charge and leach with, the latter giving a more concentrated solution, in the case of low-grade ores, with the advantages of cheaper precipitation and collection. J. W.

(2) *A Sand Filter for Chlorination Barrels. By* JOHN E. ROTHWELL. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., page* 274, *with* 3 *figures.*

Many improvements have recently been introduced to hasten the chlorination process for gold-extraction. This device has for its object the facilitating of the washing and filtering. The writer has designed a sand-filter to take the place of the expensive woven-asbestos cloth as a filtering medium in large chlorination barrels. For a barrel with a capacity of 5 tons of ore, the surface of the filter is placed 11 inches above the bottom of the barrel, and has an area of about 30 square feet. All parts of the filter-frame are made, preferably, of maple wood, which is close-grained, and, on soaking well in a light oil to prevent absorption of solution, will last a long time.

The sand used in the compartments is ordinary crushed quartz, of a size between 3 and 8 meshes screen. It is put into each compartment together with a small square of asbestos or gunnysack, so as to form a greater obstruction than the sand makes, that at first the pulp will not be washed through; then, after a few charges, a certain amount of sand from the pulp having accumulated in the filter above the cloth, it is no longer necessary, and, if of gunnysack, it is soon destroyed, leaving a perfect filtering medium.

In practice, the filter is said to work perfectly and to be a great improvement on the asbestos cloth formerly used, besides being much cheaper to keep in working order; moreover, it is not liable to clog. A charge of 5 tons of ore, crushed to 24 meshes screen, which forms a depth of 30 inches on the filter, is thoroughly leached in two hours with a pressure of from 20 to 30 lbs. per square inch.

J. W.

THE CYANIDE PROCESS.

(1) *The Chemistry of the Cyanide Process: Is Zinc Potassium Cyanide a Solvent for Gold? By* J. S. C. WELLS. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., pages* 584-585.

The statement that gold is soluble in a solution of the double cyanide of zinc and potassium ($ZnCy_2$, 2 KCy) was first made, so far as the author knows, by Mr. Feldtman, in September, 1894. At first glance, the statement appears paradoxical, seeming to be a reversal of the action taking place in the zinc-boxes; but, in the latter case, there is always an excess of zinc present, it having a greater affinity for cyanogen than gold has. The author prepared zinc-potassium cyanide solution by digesting an excess of zinc cyanide for two weeks with a 0·5 per cent. solution of potassium cyanide, and experimented on thin pieces of gold foil of known weight. His results are given in tabular form, and they prove that zinc-potassium cyanide is undoubtedly a solvent of gold. Comparison of four tests made with this solvent and tests made with potassium cyanide, and cyanide plus potassium hydrate, show that the average amount of gold dissolved by the double cyanide was 2·45 milligrammes, and by the potassium cyanide 3·44 milligrammes in 24 hours.

The claim made by Mr. Feldtman that the $ZnCy_2$, 2 KCy is decomposed by KHO into KCy and potassium zincate is not borne out by the author's experiments.

To conclude, the author finds:—(*a*) That zinc-potassic cyanide is a solvent of gold; but of less power than potassic cyanide alone. (*b*) Zinc-potassic cyanide is not decomposed by alkali into potassium cyanide and potassium zincate. (*c*) Zinc-potassic cyanide in presence of potassium cyanide can have no solvent action on gold, and therefore is valueless in the ordinary cyanide process. (*d*) The test with silver nitrate in presence of potassic hydrate does not show the cyanide available as a solvent of gold, but the total amount of cyanogen in the solution.

J. W.

(2) *The Cyanide Process of Gold Extraction in the United States.* ANON. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., page* 49.

The cyanide treatment of gold ores is at last making satisfactory progress in the United States. Not only has the Mercur mine in Utah made a practical success, but the Standard Mill, in Bodie, California, is now treating 110 tons of tailings per day by the use of cyanide. These tailings contain gold worth 16s. to 18s. per ton, and silver averaging 2·4s. per ton.

The extraction obtained is from 70 to 75 per cent. of gold and 25 to 30 per cent. of silver, with a very low consumption of cyanide. J. W.

(3) *Gold Extraction at the Waihi Mine, New Zealand.* ANON. *Australian Mining Standard*, 1895, *vol. xi., page* 494.

Much remarkable success has attended recent operations at the above mine. Previously the gold saved from the ore was just a quarter to one-half of the total gold contents. The mill was turned into a dry crusher, then it was found that 66 per cent. of the gold was saved by mercury with the finer crushing. Ultimately the cyanide process has been adopted, and this process has done much for the mine; but the management admit that fine crushing has been the real secret of success.

J. W.

GYPSUM IN NEWFOUNDLAND.

ANON. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., page* 201.

Perhaps in no part of Eastern British America is gypsum so extensively distributed as on the west coast of Newfoundland, mainly in the Codroy Valley and about St. George's Bay; but in large, or payable working quantities it occurs only in three places—one on Fishel's Brook, about 2 miles inland from where the brook flows into St. George's Bay, 35 miles east of Cape Auguille.

Another place is at Cairn Mountain, which is about 5 miles inland from St. George's Harbour, or, as it is more commonly called, Sandy Point.

The third, which is the most extensive deposit of all and the best situated for economical working and shipping, is on Kippen's or Romaine's Brook, on the north-east head of Bay St. George. It is estimated that the gypsum at this place could be quarried and put on board vessel at about 2s. per ton, and, by employing steamers, it could be laid down in New York not greatly, if anything, in excess of 7s. 2d. per gross ton. J. W.

COMPRESSED-AIR LOCOMOTIVES FOR COAL-MINES.

ANON. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., page* 127, *with* 3 *illustrations.*

A compressed-air locomotive is now at work in the Susquehanna Coal Company's mine at Glen Lyon, Pennsylvania. The main feature of the engine is the air-tanks, or receivers, of which there are two, each 29½ inches in diameter, with an interior capacity of 130 cubic feet. These tanks are cylindrical in form, with convex heads. The horizontal seams are treble butt-riveted and the heads are double rivetted. Each reservoir is tested to carry a regular pressure of 600 lbs. per square inch. The tanks are provided with reducing-valves, and there is an auxiliary reservoir, from which air is supplied to the cylinder at a pressure of 100 to 140 lbs. The cylinders are 7 inches in diameter, with 14 inches stroke. The length of the engine over all is 17 feet 6¾ inches, its width 62 inches, and height above the rail 60 inches. The total weight ready for service is 18,500 lbs. Engines of this class have so far given satisfaction wherever they have been used.

J. W.

ILLUMINATING-GAS FROM WOOD.

ANON. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., page* 416.

The town of Deseronto, in Canada, where there are several large lumber-mills, is partially lighted by gas made from sawdust. The sawdust is charged into retorts, which are heated by wood fires, the gas from the retorts passing into a series of coils, and thence into the purifiers, which are similar to those used for coal-gas. Lime is the principal purifying agent employed. When the gas passes out of the retorts, it possesses an odour less disagreeable than that of the smoke from a fire of green wood or leaves. The works in use are small, turning out daily 19,000 cubic feet of gas, for the production of which about 2 tons of sawdust are required. A man and boy furnish all the labour needed at the works. The gas in an ordinary burner gives an illumination of about 18 candle-power. The best quality comes from resinous woods. The sawdust leaves a residue of 20 per cent. by weight of charcoal. M. W. B.

IRON-ORE IN SWEDEN.

Schweden's Eisenerzlagerstätten und ihre Bedeutung für die deutsche Eisenindustrie. *By* — TIEMANN. *Dingler's Polytechnisches Journal*, 1895, *vol. ccxcviii.*, *page* 48.

At Grängesberg, specular ore and magnetite are found, the first-named being worked from shafts, and the magnetite from surface-quarries in which rails of normal gauge are laid down so that the ore can be loaded direct from the tipping trucks into railway-waggons for export. The whole of the power—with the exception of that necessary for pumping, which is obtained from six waterwheels coupled to the pumps by means of rods—is derived from dynamos driven by four 100 horse-power turbines some 7 miles distant from the mines. The current of 5,000 volts is reduced by transformers to 85 volts. The specular ore is smelted in the neighbourhood, the magnetite being shipped abroad from Oxelösund.

At Gellivara, the ore occurs in three forms: specular ore, containing much apatite, and two others with lower percentages of phosphorus, all of them being worked from surface quarries. The port of shipment, Luleå, is provided with extensive mechanical appliances for loading the ore into vessels.

Swedish ore is said to be replacing the German Oolitic ironstone in the smelting works of the Ruhr district, the shipments having risen from 963 tons in 1870 to 455,093 tons in 1893. C. S.

THE BROWN-DE-CAMP COLLECTOR FOR LEAD FUMES.

ANON. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx.*, *page* 373, *with illustration.*

The Brown-de-Camp form of condensing-chamber has been working at the Omaha and Grant Smelting Works, in Nebraska, for about a year, and is said to give great satisfaction.

The collection of mineral dust from fumes by cooling and passing through textile fabrics, such as bags, has been in use for fifty years. In this case the straining fabric is arranged in a series of inclined planes, meeting at top and bottom in a zig-zag fashion, as seen from the end. Suspended between the converging walls of these peaked ceilings are oscillating shafts extending the entire length of the building and projecting a short distance through the walls. From these shafts a series of beaters are suspended, and by means of a lever secured to the projecting end of the shaft on the outside of the building, these beaters are oscillated, striking the canvas walls with sufficient force to dislodge the accumulated mineral dust, which falls to the floor of the room.

It is estimated that under most favourable conditions there is a loss of about 6 per cent. of lead by volatilization. The actual saving in two compartments, having a total area of about 80,000 square feet straining fabric, from seven stacks 42 by 12 inches, averages a little over 100 tons of metallic lead per month, carrying about 10 ounces of silver per ton. This amount is practically 6 per cent. of all the lead charged into the smelter stacks, yielding a net income of about £1,200 per month at the present price of lead and silver.

This device can be applied to lead-smelters, zinc-white, and lead-works, and also to dry-crushing gold and silver mills. In the roasting of heavy sulphide ores there is too much sulphurous acid to admit of its use; but for condensing fumes from lead-smelters it is said to have proved a perfect success, and comparatively inexpensive device to keep up. J. W.

HARTVILLE IRON-ORE DEPOSITS IN WYOMING, U.S.A.

By E. P. SNOW. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx.*, *pages* 320-321, *with map.*

The Hartville iron-ore deposits are situate about 100 miles north of Cheyenne. At the Chicago Exhibition the Hartville ores obtained an award as the best in quality, after thorough chemical and furnace tests. The mineral was shown to be a red hæmatite, and was classed as a Bessemer ore. A new importance is now given to the above deposits, owing to the pressing demands upon the iron resources of North America.

The belt of ore is situated on the northern bank of the Platte river in Laramie County, Wyoming, and the centre of the belt is about 13 miles from the nearest station on the Cheyenne and Northern Railroad. The nearest outcrop of the ore is about 8 miles from the railroad at Fairbank, where copper was smelted some years ago. The deposit can be traced over an area of about 18 miles in length, and in width varies from 2 to 3 miles. The iron ore is found in the slates or between the limestone and slate, and, so far, appears to exist in immense masses or continuous lenses of unknown depth. On one mine, a shaft has been sunk 150 feet through a body of solid iron ore without reaching the bottom of the deposit; and at this mine, the Sunrise, one can walk 1,100 feet upon an outcropping ledge of iron ore, all visible, with a width of from 200 to 300 feet.

The curious fact has recently come to light that the red iron deposits of Hartville were a resort of the Indian tribes for war paint long before the advent of the white man. Many Indian relics have been unearthed, and, in one claim, an Indian paint-mill was found, with various war implements, about 20 feet underground.

Little development work has yet been done, and Hartville is still only a prospecting camp. Its advantages are: proximity to the railway, which can be reached over easy grades; good limestone for flux is found adjoining the ore; timber is plentiful at a distance of 8 to 10 miles; water-power can be obtained at Fairbank, where the river Platte emerges from the mouth of the canyon; lastly, a good smelting coal can be bought at 8s. per ton for a blast-furnace situated at Cheyenne. J. W.

MAGNETIC SEPARATION OF IRON ORE.

By CLINTON M. BALL. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx.*, *page* 345.

The author describes the Ball-Norton electro-magnetic separator, and also gives descriptions of a number of the plants built and experiments made for magnetic separation, notably those at Benson mines in St. Lawrence county, New York; at the Jayville mine, in the same district, and at Mineville in Essex county, New York.

It is noted in the paper that at a moderate estimate, the ore-crushing capacity of such plants in the Adirondack region of New York and in New Jersey and Pennsylvania, is equal to over 1,000,000 tons of high-grade concentrates per annum. J. W.

THE MICA MINES OF GAYA, BENGAL.

ANON. *Indian Engineering*, 1895, *vol. xviii.*, *page* 229.

The only mica mines worked in Bengal are those of Singar and Supahi in the Nawada sub-division of Gaya. Their output appears to be decreasing, as the figures for the last three years show:—1892, 800 maunds; 1893, 640 maunds; and for 1894, 547 maunds. J. W.

ONYX MARBLES.

By COURTENAY DE KALB. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., page* 368.

The term, onyx marble, is more a commercial than a scientific distinction, since a stone is only entitled to the name from its qualities of texture and beauty which fit it to serve as an ornamental stone. The general name of travertine includes all such deposits, except finely crystallized calcite and arragonite.

The requisite commercial qualities for onyx marble are homogeneity of texture, freedom from pores and cracks, translucency, beauty of colouring, and proper size of perfect blocks (the usual minimum limit for thickness being 1 inch, and for superficial area 1 foot square). The price varies, according to the grade of the stone, from 2s. to £10 per cubic foot.

The amount of onyx marble produced at present in the United States is very small, and comes entirely from California, Utah, and Arizona. The most important source of supply is Mexico, formerly from the State of Puebla; but now, the largest quarries are those at New Pedrara in Lower California. J. W.

CLOSE SIZING BEFORE JIGGING.

By R. H. RICHARDS. *Transactions of the American Institute of Mining Engineers*, 1894, *vol. xxiv., pages* 409-486.

The first, and most important, law of jigging, and that which governs the greater part of the work of jigging, is known as the law of equal-settling particles. The author tabulates the results of various experiments on velocities of fall in water, etc., and comes to the conclusion that this law is not, under any circumstances, the whole law of jigging.

The second law is that of interstitial currents—the effect of confined space upon falling particles. If D be the diameter of the falling particle, and d that of the space in which it has to fall, it is found that the larger the value of $d \div D$, the greater is the retardation, or loss of velocity, by the particle.

If particles of quartz be represented by large circles, and those of equally-settling galena by smaller circles, then when these mixed particles are settling *en masse*, or are held in suspension by a rising current of water, each particle may be considered to be falling in a tube, the walls of which consist of the surrounding particles. The author constructed a pointed tube apparatus to ascertain the extent this law acts upon irregular particles, and describes, with tables, the results of his experiments. The ultimate result of the pointed tube, which resembles the *spitzlutte*, and the pulsion action of the jig, is to associate together particles of the two minerals that are to be separated, in which the ratio of the grains lies in one of these three classes: The lesser, higher specific gravity grain is (1) smaller than, (2) equal to, (3) greater than, the quartz interstices.

The third law is that of acceleration, and to test its effect the author designed a pulsion-jig, with which he carried out several experiments, but failed to discover any gain over and above that due to interstitial currents. He feels, however, that acceleration must, logically, produce some result.

The fourth law is the law of suction. In order to study it the author constructed a movable sieve-jig and submitted each test to full pulsion with much, with little, and with no suction.

The two chief reactions of jigging are pulsion and suction:—

The effect of pulsion depends upon the first three laws. The chief function of pulsion is to save the larger grains of the heavier mineral, or the grains which settle faster and farther than the waste.

The effect of suction depends upon the interstitial factor of the minerals to be separated; if this be above 3·70, suction will be efficient and rapid; if less than 3·70, suction will be much hampered and hindered. The chief function of suction is to save the particles that are too small to be saved by the laws of equal-settling particles, and of interstitial currents, acting through the pulsion of the jig.

For jigging mixed sizes, pulsion with full suction should be used; but for closely sized products, pulsion with a minimum of suction should be made use of. The degree of sizing needed as a preparation for the most perfect jigging depends solely upon the interstitial factor of the minerals to be separated.

To effect the most perfect separation, close sizing must be adopted, and the closer the sizes are to each other the more rapid and perfect will the jigging be.

A. W. G.

NOTES ON CERTAIN MAGNETIC PHENOMENA IN GOLD-BEARING SLATES.

By C. A. MEZGER. *Transactions of the American Institute of Mining Engineers*, 1894, *vol. xxiv., pages* 40-42.

The ore-bodies at Raposos, Brazil, are exclusively chimneys, mostly cylindrical, following the dip of the argillaceous slates, without veins or any visible connexion with each other. They are composed of quartz with 8 to 10 per cent. of pyrite and pyrrhotite, and various iron oxides. The slates contain everywhere some 2 per cent. of magnetite; concentrations of magnetite in layers in the slate are found, but these are poor in gold. It was found impossible to use the ordinary English theodolite for surveying, owing to the declination.

A regular survey was made with a Freiberg theodolite (without needle) and based upon the astronomical meridian, from which all declinations were obtained. A cross-cut adit was driven against a group of chimneys which had been worked formerly from the surface. The declination in the cross-cut was pretty uniformly 3 degrees east; but for a length of 8 to 10 feet in it, there was a declination of 9 degrees, and at this point some good ore had been struck.

At another place in the cross-cut the needle showed the same disturbance, and on blasting some of the rock away some good gold ore was found, indicated by no other signs but the disturbance of the needle.

The author examined the slates very carefully, but could find no difference in them, and comes to the conclusion that the magnetic polarization of the small crystals of magnetite is parallel where they occur with gold, and that it is in all directions at other places so as to form ore-magnets in the first and to compensate each other in the second case. He leaves the question open whether there is a causal correlation between the gold and the parallel polarization. A. W. G.

ELEMENTARY COMPOSITION OF PETROLEUM.

Ein Beitrag zur Kenntniss der elementaren Zusammensetzung der Erdöle. By C. ENGLER and L. JEZIORANSKI. *Berichte der deutschen chemischen Gesellschaft*, 1895, *vol. xxviii., pages* 2501-2505.

It is usually assumed, from the constitution of the more volatile fractions, that American, Alsatian, and Galician petroleums consist of hydrocarbons of the methane series, and Baku and Oelheim oil of those of the naphtha series, without tak-

ing into consideration the composition of other hydrocarbons present in both varieties. The authors show, however, by the results of analyses of various oils effected by them, that the higher fractions contain a greater percentage of carbon and correspondingly less hydrogen than the saturated hydrocarbons, and may therefore be considered as composed of unsaturated hydrocarbons, a view confirmed by the phenomena observed when petroleum is artificially prepared by distilling fats under pressure. In this process a considerable amount of water is given off, whereas in the production of saturated hydrocarbons only carbon dioxide would be evolved.

The actual constitution of these unsaturated compounds in the heavier oils is still undetermined, as is also their method of production, but, as regards the latter, the probability is that they are formed at the same time as the saturated hydrocarbons instead of being after-products due to polymerisation.

The average percentage of carbon in the fractions boiling above 200 degs. C. was found to be 87 per cent., thus showing a greater proportion of this element than is contained in the ethylene series (85·7). The lighter fractions—boiling below 150 degs. C.—contained 83·3 to 84·4 per cent. of carbon, and those between 150 and 200 degs. C. 84·4 to 84·7 per cent. C. S.

ITALIAN PETROLEUM.

Les Pétroles italiens. *By* C. Flaunet. *Moniteur des Produits Chimiques*, 1895, *vol. xxv.*, *No.* 18.

The most important oil-producing districts in Italy are Montanaro di Piacenza, Rivanozzuno, near Voghera, Zocca-Casanria, and San-Giovanni-Incarico. Montanaro oil is a yellowish, slightly fluorescent liquid, neutral, and free from sulphuretted hydrogen. It has a specific gravity of 0·7849 at 15 degs. C., flashes at 8 degs. C., and yields the following approximate percentage of fractions:—

(1) 44·7 of light oil (specific gravity 0·754), flashing at 15 degs. C., forming benzene.

(2) 19·8 of lighting oil distilling at 127 to 150 degs. C. (specific gravity 0·787), flashing-point 5 degs. C. This is used for naphtha lamps.

(3) 22 of burning oil, with a density of 0·812, a flashing-point of 40 degs. C., and a boiling-point of 150 degs. to 203 degs. C.

(4) 14·4 of heavy oil used for lubricating (specific gravity 0·862, and boiling-point above 203 degs. C.)

Rivanozzuno oil comes from a spring of iodated mineral water, accompanied by natural gas (apparently of the methane series). Its specific gravity (0·9132) is greater than that of American and Russian oils, but lighter than that of the Egyptian oil. The oil is highly coloured, viscous, and fluorescent, containing sulphuretted hydrogen, and flashing at 92 degs. C. The yield on distillation is: 22 per cent. of fractions boiling below 230 degs. C., with a specific gravity of 0·8843, and a flashing-point of 86 degs. C.; 33 per cent. of oil boiling between 235 and 270 degs. (specific gravity 0·9047, flashing-point 110 degs. C.; colour yellow, fluorescent); 37·1 per cent. boiling at 270 to 380 degs. (specific gravity 0·9302; colour, deep yellow; flashing-point 140 degs. C.); and 7·7 per cent. of a viscous, dichroïc residue, specific gravity 0·953, and flashing at 190 degs. C.

Zocca-Casanria oil is a blackish bitumen of fœtid odour, with a specific gravity of 0·951, and flashing at 86 degs. C. On distillation it gives about 3 per cent. of acid water. The residue left after some two-thirds of the bulk has distilled over, is readily soluble in light coal-tar oils and makes a black varnish impervious to the

action of acids. A large volume of sulphurous gas is evolved during distillation, and is purified by passing it through a solution of lead acetate. The distillates, amounting to 63·5 per cent., lose 34·7 per cent. in weight on treatment with sulphuric acid and soda, leaving 23·4 parts of burning oil.

San-Giovanni-Incarico petroleum is also a blackish fœtid bitumen, of a specific gravity of 0·974, and yields on distillation 69·6 per cent. of oil, 28·3 per cent. of pitch, and 2·1 per cent. of gas containing a large proportion of sulphuretted hydrogen. The distillates have also an offensive odour; they yield a burning oil of a specific gravity of 0·921, and flashing at 85 degs. C. C. S.

ORIGIN OF GALICIAN PETROLEUM.

Le pétrole de Galicie, hypothèses concernant sa formation. By H. HÖFER. *Revue Universelle des Mines*, 1895, *vol. xxxi.*, *page* 191.

In the eighteenth century, several theories on the origin of petroleum were advanced by writers long since forgotten, whose works have been unearthed by the author. Mr. F. von Baroldingen (1778) attributed the formation of oil to the subterranean distillation of coal at high temperatures, citing in support various circumstances since shown to be irrelevant. Mr. Haquet, in 1794, held that animal remains formed the chief source of petroleum, and commented on the genetic relation between petroleum and salt, but his premises were unsound, since in the Carpathians the quantity of animal remains found is much smaller than he imagined, and the chief oil-layers in Galicia occur in the Eocene, which is poor in fossils, and underlies the Miocene, wherein the salt-beds are found. Still, to this investigator belongs the honour of being the first advocate of the animal theory (which is, after all, the only admissible one), for the apparent contradiction, due to the lack of animal remains in petroliferous strata, is explainable by the assumption that the solid portions of the animal (consisting largely of carbonate of lime) have been dissolved by water charged with carbonic gas, which gas was evolved in large volumes —proportionate to the quantity of animal matter present —during the process of transformation of this matter into petroleum.

Mr. P. C. Kluk maintained that the earth alone was the source of such bodies as petroleum, asphalt, amber, copal, sulphur, coal, etc., and that to the diminution of fertility was due an accumulation of fatty matters in the earth, into which they descended gradually by their own weight, and coming into contact with other matters underwent transformation, a condition favoured by the Deluge.

C. S.

PETROLEUM IN RUSSIA.

Neuer Petroleumfund. ANON. *Der Seifenfabrikant*, 1895, *vol. xv.*, *pages* 787-788.

Recently a new oil-field has been discovered in the plain between Wladikawkas and Petrowsk, in the vicinity of Grósnoje, where a well suddenly began to spout at a rate exceeding that of the most famous of the Baku fountain-wells. The daily production is taxed at about a million poods (16,000 tons), and, being utterly beyond control, the outflow quickly filled the tank constructed for the reception of the oil, which therefore began to run all over the surrounding land, flooding the streets in the Cossack town and flowing into the river Restjanka. The air was filled with oil-spray and vapour, rendering respiration difficult and the danger of conflagration so imminent that no fires were allowed to be lighted. The pressure on the dam of the tank proved too great for its strength and it gave way, the oil pouring out of a breach about 12 feet wide and 3 feet in depth. C. S.

PETROLEUM IN ASSAM.

ANON. *Indian Engineering*, 1895, *vol. xviii.*, *page* 40.

The borings for petroleum at Makum, in Assam, have been stopped, as no satisfactory results were obtained. At Digboi, however, thirteen bore-holes have been put down and seven wells are at work. J. W.

PETROLEUM IN UPPER BURMA.

ANON. *Indian Engineering*, 1895, *vol. xviii.*, *page* 181.

The total quantity of petroleum extracted in 1894 was 10,276,218 gallons, against 8,698,424 in the previous year. Of this quantity, Arakan contributed 256,701 gallons, against 308,091 during the same period of 1893. The old restriction prohibiting new wells being sunk within 300 feet of old ones has been abolished, as subsequent experience gained shows that new wells sunk within 60 feet of existing wells do not reduce the output of the latter. A very good yield is expected from the new wells at Kyaukpyu and Yenangyaung during the current year. J. W.

PETROLEUM IN PERU.

Le Pétrole au Perou. By CARLOS B. CISNEROS. *Mémoires de la Société des Ingénieurs Civils. Bulletin*, 1894, *vol. xlvii.*, *pages* 897-898.

The author states that petroleum occurs at many points of the Peruvian territory, but the most important, and so far the only worked, deposit is that in the department of Puira. The area of the Puira oil-field is reckoned at 32,000 square kilometres (7,907,200 acres) and it is barely 10 miles distant from the Pacific sea-board. The oil is got very near the surface, sometimes within 30 feet of it, and the deepest shafts never go below 800 feet. The work of boring is much facilitated by the character of the strata which, down to 150 feet, consist of sands, impervious clays, conglomerates, and slates, and the price of boring (5s. per foot in depth for a diameter varying from 4 to 12 inches) is only half of that paid for the same work in the United States. As most of the borings give vent to running springs [of oil] there is reason to believe that we have here to deal with vast underground lakes of petroleum.

Several refineries have been started, the three most important being those of Zorritos, Heath, and Talara—the last-named is the largest of all. That and the Zorritos works account respectively for 30 and 14 wells out of the 49 at work in the oil-field. The plant is of the most modern description, and produces kerosene and all its derivatives.

At the Talara refinery, the storage-tanks have a capacity of 220,000 gallons, and there are several retorts which can distil at once more than 28,600 gallons. The refinery uses its own steamers for carrying the oil. At Zorritos, the shafts are within a few feet one of the other and of the sea-shore. Each of the two works is provided with a harbour of its own, protected by good breakwaters and lighthouses, and has, moreover, Decauville railways, telegraph, telephone, and electric-lighting plant.

The total annual production of Peru at the present time may be estimated at 17,600,000 gallons, and would thus make that country the sixth greatest petroleum producer in the world. Most of the oil is consumed in Peru itself, on the railways and in the metal foundries. Small quantities are exported to the neighbouring States and to China. But it seems quite probable that Peru will one day compete with the Caucasus for the supply of the world's markets. O. S. E.

FLORIDA PEBBLE-PHOSPHATES.

By E. W. CODINGTON. *Engineering and Mining Journal [New York]*, 1895, *vol. lx., page* 345.

The district in which these deposits occur is bounded by the Peace river and the Gulf of Mexico. The author describes the different methods of mining, removing the overburden, and the phosphate-conglomerate, also the appliances for drying rock, and preparing it for market. The area of the deposits is estimated at about 5,000 acres.

A phosphate-deposit to be workable, under existing conditions, and assuming the use of the latest machinery, must fulfil the following specifications:—On the basis of a phosphatic stratum of 12 feet in depth, averaging 600 lbs. of dried pebble to the cubic yard of mass, the overburden should not exceed 3 feet if it contain sand-conglomerate, or 12 feet if free from the conglomerate. The cargo-samples of rock should not contain less than 65 per cent. of phosphate of lime, nor more than 3 per cent. of iron oxide and alumina; lastly, the position should be such as to present no special difficulties in mining. J. W.

PUMICE-STONE MINING IN THE LIPARI ISLANDS.

By NORMAN DOUGLAS. *British Foreign Office Report, No.* 378, *Italy*, 1895.

Pumice occurs on most shores of the Tyrrhenian Sea, but that of commerce is now almost exclusively obtained from the island of Lipari, lying to the north of Sicily. This mineral is a trachytic lava, rendered light and scoriaceous by the escape of gases, and every gradation can be traced from this condition to the heavy vitreous matter of similar composition known as obsidian. Good pumice contains:—Silica, 73·70 per cent.; alumina, 12·27 per cent.; potash, 4·73 per cent.; soda, 4·52 per cent.; oxide of iron, 2·31 per cent.; water, lime, etc., 2·47 per cent.

The best pumice-stone in Lipari is the product of the Monte Chirica volcano, with its accessory craters, Monte Pelato and Forgia Vecchia. In excavating the mineral, tunnels or galleries are dug into the layers of denuded lapilli and ashes that have gradually covered the pumice. The mineral is sometimes found near the surface, at other times under a layer of white tufa. Digging is not difficult. The tunnels are so narrow that two men can barely pass; they are lighted at intervals by small terra-cotta lamps of antique form. The number of tunnels actually working has been estimated at 250, but they vary greatly in size. The number of workmen also fluctuates, according to their personal requirements and the season of the year, but has been estimated at about 1,000, of whom 600 are miners. The deposits are so extensive that the supply is practically inexhaustible. Pumice washed up by the sea is hardly ever collected nowadays. J. W.

NOTES ON THE UNWATERING OF A FLOODED MINE, AND ON THE PERMEABILITY OF NATURAL STRATA TO AIR.

By B. S. RANDOLPH. *Transactions of the American Institute of Mining Engineers*, 1894, *vol. xxiv., pages* 21-25.

Unwatering of a Flooded Mine.—The mine referred to is one of the Consolidated Coal Company's slopes into the big vein or Pittsburg coal-seam, near George's Creek in Maryland. The slope had been driven down the dip of the seam, making such an angle with the line of greatest dip as to give a grade of 1 to 10 per cent. The coal was worked from each side of the slope in successive lifts.

From the top of the slope down to the fourth lift—a distance of 4,000 feet—the water is drained by gravity, through a heading, into the adjoining mine; but below this point the water was pumped up into this same heading and flowed off by gravity.

During March, 1891, these pumps were overpowered by a sudden inrush of water, and the lower workings were temporarily abandoned and allowed to fill. It was then determined to sink a shaft to reach the seam near the foot of the slope and to put in a large pumping-plant. While the shaft was being sunk and the lower levels allowed to fill, an area of coal lying below the fourth lift was worked in such a way that the water from that part of the mine already opened could not flow into it, and the output was thus maintained. During this time the lower levels filled up to the fourth lift, giving a head of about 80 feet when the water was drawn off.

The coal in this district is very soft, friable, and full of slips lying at every angle. To approach this body of water with a head of 80 feet through such material was a hazardous undertaking, so the following method was adopted:—From the foot of the shaft a heading was driven in the seam to within 100 feet of the original slope, and another heading about 40 feet higher up, and these headings were connected by a vertical winze. A third heading was started 12 feet from the bottom of this winze to a point immediately above the slope. Several pieces of 4 inches cast-iron pipe were sunk in the floor of this latter heading, right over the slope, and made fast with cement, etc.; gate-valves were then bolted to the ends of these pipes, and holes bored through them into the water. On the drills being withdrawn and the valves closed the flow of water to the shaft could be controlled as desired. When the water had run down to the level of the valves the intervening rock and coal were gradually broken down.

The Permeability of Natural Strata to Air.—Previous to the flooding of the mine the slope had been driven down about 2,500 feet below the fourth lift without opening off any workings to the north side. At this point (the sixth lift) headings were driven north and south. In the north heading, a second heading A was driven to the rise about 200 feet away from the slope and parallel to it, and out of this heading, rooms or workings were started. The face of these rooms was about 40 feet above the bottom of the heading A, and a considerable quantity of air was entrapped in them by the rising of the water. For quite nine months the water would have a head of 40 feet in these rooms, and subsequent examination proved that they had been quite full of water, and that the air must therefore have been expelled through not less than 200 feet of solid coal.

Whilst these workings were abandoned the output was kept up, as already mentioned, by separate workings below the fourth lift, and these were gradually extended during the pumping of the water till they holed into the rooms below. At the time of holing, the water in the slope was about 10 feet lower than the face of the old rooms; but a violent rush of air into these rooms occurred and the water suddenly rose about 7 feet vertically in the slope. Thus, the air had not been able to follow in through the coal as fast as the water was pumped out, and the result was a vacuum equal to a water-column 7 feet high. The time during which the water was lower in the slope than the face of the rooms, and therefore, during which the air was being drawn back into the rooms was about a fortnight.

Some years ago the writer drove into a heading in the same seam which had been driven over an anticlinal dome. The heading had been filled with water at a head of more than 80 feet, and yet the air in the crown of the dome had never been expelled. In this case the roof—a slate rock—was at right angles to the stratification.

It is therefore to be inferred that air will pass slowly through soft semi-bituminous coal, but will not pass to a perceptible degree through slate rock at right angles to the stratification. A. W. G.

AUSTRIAN SAFETY-LAMP TESTING APPARATUS.

Untersuchungs-Apparate für Grubensicherheitslampen beim gräflich Wilczek'schen Berybaubetriebe in Polnisch-Ostrau. *By* Jos. Mauerhofer. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1895, *vol. xliii. pages* 654-655, *and plate XX.*

At Count Wilczek's collieries in Polnisch-Ostrau, Wolf safety-lamps, wherein the air is admitted from above, are used, and the igniter is of pattern No. 90. The testing apparatus is worked as follows: the lamp is first of all placed over a gutta-percha receiver, so arranged that the bottom of the lamp fits closely into it. The receiver stands on a column fixed to a leaden slab, and is thus perfectly stable. Into the bottom of the receiver is fitted a stopcock communicating, by means of an india-rubber pipe, with the air-compressor. The air-compressor may be regarded as consisting practically of three parts—a fixed central portion of cast-iron, solidly mounted on a table, and two ordinary sheet-iron dome-topped cylinder-ends, which are well ground on to the outer surface of the compressor, and are stiffly hooped together by flat-iron bands. On both sides of the cylinder, a coupling rod, which turns round a central bolt, fastens on to the middle of the above-mentioned bands, and the whole system is driven by a hand fly-wheel which transmits the motion to the crank. Suction-valves are inserted in the summits of the dome-topped cylinder ends, and are alternately opened and shut by spiral springs, while the cylinder-ends slide to and fro on the central and fixed portion. On this central portion are fixed in a suitable manner the two pressure-valves. At the top is screwed a hollow cylinder into which open six brazen nozzles from as many india-rubber tubes. Thus, at one and the same time, six different safety-lamps may be connected up with the apparatus.

Another apparatus, answering the same purpose as the foregoing, but differing from it in the method of compressing and introducing the air, is in use at the Emma pit. Here, instead of a compressing-cylinder, something of the nature of a gasometer is used. The lamp-testing room is shut off by a 12 inches wall from the air-compressing apparatus. This consists of a sheet-iron bell, which is suspended so as to dip below the surface of the water contained in a cylindrical recipient sunk in the floor. A hand-winch, connected with a wire rope running on pulleys to the lamp-testing room, raises the bell when required. The bell is counterbalanced by weights running on blocks; as it rises the suction-valve opens automatically, and the required amount of atmospheric air flows into the bell. On the wire rope being released, the bell sinks by its excess of weight, the suction-valve closes automatically, and the air is forced into the main pipe. The latter, led through a suitable opening in the wall, debouches into a small pressure-regulator, mounted on a column. Thence through six distributing-tubes the air makes its way to the corresponding gutta-percha receivers, in which are placed the lamps under investigation. An air-nozzle flattened out in semicircular shape at its upper end, so that it embraces half of the circumference of the lamp, is fixed thereto at the point where the upper portion of the lamp screws on to the lower. By means of another air-nozzle, tapering off in the usual way, with a diameter of about $\frac{1}{10}$ inch, the entire external surface of the lamp may be tested with compressed air. O. S. E.

RE-WORKING OF ANTHRACITE CULM-BANKS.

By ARTHUR W. SHEAFER. *Transactions of the American Institute of Mining Engineers*, 1894, *vol. xxiv., pages* 364-371.

The author gives eight instances of old culm-banks which are being reworked, and which in some instances are yielding 60 per cent. of marketable coal. The results obtained are tabulated according to the different sizes of small coal down to buckwheat, which will pass through a ½ inch screen mesh. The author thinks that there will be a demand for sizes smaller than buckwheat in the near future, which will still further increase the yield from these so-called refuse banks.

A. W. G.

SILVER DISTRICT OF TEHUILOTEPEC, GUERRERO, MEXICO.

By EDWARD HALSE. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., pages* 197-199.

Tehuilotepec (meaning mountain of crystals) was founded early in the eighteenth century. It lies about 3 miles east of the town of Tasco, the two forming one of the first mining centres founded by the Spanish conquistadores.

The mine which is worked most at present is that known as Los Remedios. The principal workings are about 1,500 feet south-east of the church of Tehuilotepec. The ore consists of argentiferous marcasite, argentite, and dark ruby silver, with a little blende and chalcopyrite in a gangue of quartz and calcite. The pay streaks run about 200 ounces of silver and 0·12 ounce of gold, while the low-grade ore (hand-picked) goes about 40 ounces of silver, with only traces of gold per short ton. At the San Augustin adit, the vein is 8 to 10 feet thick, and contains much calcite in large rhombohedral crystals. The ore is fine grained, argentiferous galena, marcasite (always silver-bearing), with some copper pyrites, zinc blende, and crystals of ruby silver.

The principal vein in the Tasco district proper is that known as Pedregal. It lies immediately north-east of the town, and is the deepest in the district, the main shaft having, it is said, a depth of 984 feet. A large quantity of fair grade ore is said to have been left in the bottom workings. The high grade ore yields from 185 to 237 ounces of silver per short ton. Between the two ribs there is ore of ordinary grade. The whole vein is said to average over 100 ounces of silver per ton.

At Mr. Romero Rubio's reduction works in Atlistac and Santa Barbara, four processes have been tried:—(1) Patio or cold amalgamation process; (2) Barrel amalgamation or Freiberg process; (3) Pan or hot amalgamation process; and (4) Smelting in a blast-furnace.

In the author's opinion, the solution of the problem appears to lie in wet crushing and concentration in vanning-machines before treatment in the pans. The concentrates could afterwards be roasted and smelted with plumbiferous ores, etc. In some of the ores blende appears to be an abundant constituent; to eliminate this, coarse crushing and concentration by jigging-machines would be necessary before further treatment. Raw amalgamation is, evidently, a mistake.

It is an error to suppose that Tasco is either a played-out district or in its decline. The author is convinced that by opening up and exploiting the veins according to the local laws of ore-deposition therein, and by treating the ores on some such system as that suggested, large profits could be made there for a long time to come.

The discovery of new silver deposits elsewhere, especially in the northern States, has diverted attention from Zacatecas, Catorce, Tasco, and other classical

districts, but when more or less depth has been attained in the new camps considerable attention is once more likely to be directed to the older mining centres of the Republic, unless, indeed, new and richer districts be discovered in the meantime. J. W.

TINA AMALGAMATION FOR SILVER EXTRACTION.

By VINCENTE PAZOS Y SACIO. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., pages* 253-254.

It is strange that the method of tina amalgamation, as used in South America, or any other in which iron is replaced by copper in the process of amalgamation, has not been tried in the United States. If the Huanchaca method were once tried it would rapidly replace pan-amalgamation in districts where fuel is scarce, and the ore to be amalgamated is rich and rebellious. As an instance of the superiority of the tina method, the Ticapampa works may be mentioned, where lixiviation and amalgamation were carried on side by side, working on the same ore and under the same management. After some time lixiviation was given up, and all the ore is now treated by tina amalgamation.

After treating of the advantages and disadvantages of the tina as compared with iron pans, the author sums up as follows:—By using copper instead of iron in the process of amalgamation, nothing more is done than intensifying the affinities, making the same weight of reagents do more, quicker, and better work, not only on the silver compounds but also on the mercury compounds which tend to form during amalgamation, eliminating at the same time all hurtful reactions. The writer has no data of the pan and tina working on the same ore, but from results obtained in Peru, taking as a starting-point ore that has to be roasted eight hours in the reverberatory furnace, the pan and tina processes will compare as follows:—

	Pan Amalgamation.	Tina Amalgamation.
Roasting	8 hours	6 hours.
Salt	16 to 8 per cent. ...	10 to 12 per cent.
Time in pan	8 hours	6 hours.
Time in settler... ...	4 hours	4 to 6 hours.
Mercury lost	⅓rd of silver produced	¼ and less.
Silver lost	25 per cent.	20 per cent.
Fineness of bullion ...	600 to 700	900 and upwards.

J. W.

THE EFFECT OF WASHING WITH WATER UPON THE SILVER CHLORIDE IN ROASTED ORE.

By W. S. MORSE. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., page* 368.

The going-back of chlorination during the washing of roasted silver ores with water has been a serious difficulty in many leaching works, notably in the treatment of such ores by the Russell process at Aspen, Colorado. The theory of Mr. L. D. Godshall was that such reversion was due to the presence in the roasted ore of sulphurous acid, acting as a reducing agent.

The author attributes the going-back to the presence of sulphides of the base metals, which have escaped oxidation in the roasting. In the Aspen ores, the

difficulty was due, he thinks, to zinc sulphides, which were not decomposed in the rapid roasting in the Stetefeldt furnace.

Mr. Morse believes that the reactions between chloride of silver and the sulphides of the base metals are of great importance in the leaching of silver ores, either with brine, hyposulphite, or the Russell solutions. This point, he considers, has been overlooked by many investigators. J. W.

LAND SUBSIDENCE AT BRÜX, BOHEMIA.

Die Bodensenkung in der Stadt Brüx, Böhmen. By R. HELMHACKER. *Glückauf*, 1895, *vol. xxxi., pages* 1215-1217.

A considerable subsidence of land occurred on July 19th, 1895, through the breaking down of the strata overlying the workings in the brown-coal pits under the town, and the consequent escape of a large volume of quicksand contained in the shaly clay. Sixty-six houses were rendered uninhabitable, thirty-one of them being totally destroyed, and some 2,000 people were left homeless by the catastrophe.

The coal-seams underlying this district form part of the great Bohemian brown-coal-field, which here consists of only the upper and lowermost beds, divided into from two to four seams, with intermediate strata of 7½, 8, and 8 feet respectively. The main seam extends parallel with the Erzgebirge, at varying depths, being only 16 feet below the surface at a point near Brüx, but 375 feet at Kopitz, 4 miles to the north-west, 750 feet at Rosenthal, a further distance of 4 miles, and 1,000 feet deep another 5 miles further away. In thickness it averages between 50 and 80 feet, with a maximum, near Bilin, of 125 feet.

Around and under the town of Brüx the seam lies nearly horizontal, at about 325 feet from the surface, and is covered by a layer of shaly clay, interspersed with beds of quicksand (quartz-sands saturated with water), from 10 to 65 feet in thickness; and the subsidence is due not merely to the breaking of the cover-rock in the workings, but also to the cavities produced by the escape of these sands from their original position.

The workings under the town consist of two headings from the Anna shaft, worked on the panel system. The fracture occurred at a distance of 4,600 feet from the shaft, and 2,300 feet from the new winding-shaft, and it is calculated that some 2,000,000 cubic feet of sand found its way into the workings, filling up the old shaft to a depth of 30 feet, and lying in dense masses in the ways, thereby preventing the influx of water.

The effect of the subsidence at the surface was the formation of numerous holes, some of them as much as 50 feet deep, and large fissures in the ground. A considerable depression was produced at the railway-station; and part of the preliminary investigation of the seat of the disaster was devoted to ascertaining whether the safety-stowing, which should have been erected in the workings under this place, had been omitted. They have been discovered, and the feeling is therefore against relying on such means of security alone under similar geological conditions.

Several trial-borings have been made around and within the area affected, and reveal the existence of cavities from which the quicksand had escaped. A commission is carrying on the work of investigation, with a view to ascertaining the means of preventing the recurrence of similar accidents. C. S.

SULPHUR-MINING IN SICILY.

ANON. *Engineering and Mining Journal (New York)*, 1892, *vol. liii., page* 278.

The mining and fusing of sulphur is still carried on in the most primitive fashion in Sicily, partly from lack of enterprise and partly too from want of capital, which cannot be induced to invest in any undertaking on the island. In the majority of mines machinery is unknown, and in the larger and more valuable mines only pumps and hoisting-apparatus are used. Manuel labour is universal, and a great many children find employment in carrying the mineral from the mine to the surface in baskets on their heads.

A description is given of the four systems of melting sulphur in Sicily—the Calcherone, the Sinopoli furnace, the steam process, and the Gill furnace.

The mean cost of mining sulphur in Sicily is :—

	Per Ton. £	s.	d.
Mining and hoisting	1	6	4·8
Melting	0	6	4·8
General expenses	0	4	0
Total	1	16	9·6

Plus government and town dues, which reach as high as 30 per cent. of the profits.

Shipping expenses for the past three years have averaged :—

	£	s.	d.
Cartage from railway-car and storage in warehouses	0	0	7·7
Transportation on lighters	0	1	8·2
Customs dues	0	9	7·2
Chamber of Commerce dues	0	0	2·4
Total	0	12	1·5

Crude sulphur, as exported, is divided into seven different qualities or grades. The difference between two such grades amounts to little more than 1s. 3d. per ton.

Sulphur is only refined in Catania; a description is given of the Sinopoli furnace as used there. In comparing this furnace with the Calcherone system an increase of 6·5 per cent. is shown in the yield by the Sinopoli, which at the current price would give a profit of 1s. 8d., besides the improved quality. For this calculation, the price of refined sulphur at the mine is taken at the rate of £3 8s. 3d. per ton.

J. W.

MINERAL PRODUCTION OF TASMANIA.

ANON. *Australian Mining Standard*, 1895, *vol. xi., page* 489.

The total yield of gold for the year has been 58,301 ounces, of a value of £218,629, an increase of £55,921 on the previous year. The silver output has been 19,665 tons, value £196,650, an increase of £11,960. Tin and coal both show a decrease. The total value of all minerals for the past year was £715,069, an increase of £7,249.

The average number of miners employed during the year 1894-5 has been 3,334 Europeans and 455 Chinese, and the number of companies registered 70, with a capital of £254,910.

J. W.

TEMPERATURE OBSERVATIONS IN THE DEEP BOREHOLE AT WHEELING, WEST VIRGINIA, U.S.A.

ANON. *Engineering and Mining Journal (New York)*, 1892, *vol. liii., page* 454.

The Wheeling borehole was sunk by the Wheeling Development Company, and by it generously dedicated to science. It is 4,500 feet deep, 4⅞ inches in diameter and dry, and cased to a depth of 1,570 feet. The strata are nearly *in situ*, undistorted, and dipping only 50 feet to the mile. More satisfactory geological conditions can scarcely be imagined. Being dry, ordinary U.S. Signal Service maximum thermometers were used to record the temperatures, and no especial precaution taken to prevent circulation of the air. The following results were shown :—

Depth. Feet.	Tem. Fahr. Deg.	Depth. Feet.	Tem. Fahr. Deg.
1,350	68·75	3,125	88·40
1,591	70·15	3,232	89·75
1,592	70·25	3,375	92·10
1,745	71·70	3,482	93·60
1,835	72·80	3,625	96·10
2,125	76·25	3,730	97·55
2,236	77·40	3,875	100·05
2,375	79·20	3,980	101·75
2,486	80·50	4,125	104·10
2,625	82·20	4,200	105·55
2,740	83·65	4,375	108·40
2,875	85·45	4,462	110·15
2,900	86·60		

These observations, when plotted, show a slow increase for the upper half of the uncased portion, about 1 deg. Fahr. for 80 to 90 feet, whereas the lower part shows a more rapid increase, about 1 deg. Fahr. for 70 feet. The whole series gives a well defined and regular curve, with a deflection at 2,900 to 3,000 feet, where an oil-sand occurs. Practically all the rest of the uncased well is shale.

The results of observations at the Sperenberg borehole, near Berlin, which is 4,170 feet deep, the Schaladabach, near Leipsic, which is 5,740, and the Wheeling well, 4,500 feet, are as follows :—Their top temperatures are given, respectively, 48·8 degs., 51·0 degs., and 51·3 degs. Fahr.; their bottom temperatures, 118·6 degs., 135·5 degs., and 110·3 degs. Fahr.; which shows a much lower average increase in temperature in the Wheeling borehole than in the others. J. W.

OBSERVATIONS ON TEMPERATURE AND HUMIDITY OF THE AIR AT THE MAYBACH COLLIERY, SAARBRÜCKEN.

Ueber Feuchtigkeits- und Temperatur-Beobachtungen auf Grube Maybach bei Saarbrücken. By H. FISCHER. *Glückauf*, 1895, *vol. xxxi., pages* 1070-1072.

The Crown colliery of Maybach works the lowest group of coal-seams of the Saarbrücken coal-field. The middle level is 1,505 feet (459 metres) below ground, and the deep level No. 1 now in course of forewinning is 1,722 feet (525 metres) below ground. The considerable depth and the comparatively horizontal lie of the seams form all but insuperable obstacles to the irruption of surface-waters. It is true that a small quantity finds its way into the workings through fault-clefts, and through certain thickly-bedded but much fissured conglomerates. On the other hand, the high temperatures prevailing at these depths favour the rapid desiccation

of the seams. At the middle level, the rock temperature has been determined as 84 degs. Fahr. (29 degs. C.), and at deep level No. 1 as 89 degs. Fahr. (32 degs. C.). It will therefore easily be understood that all the seams in the pit are extremely dry, and when worked give rise to large quantities of fine dust; to allay this, the system of watering already described in the *Transactions* of The Federated Institution of Mining Engineers was adopted in 1888.*

In regard to the amount of water-vapour present in pit air, it will be recollected that the Prussian Fire-damp Commission found in all the deep workings visited by them that in the downcast shafts the air is well nigh saturated. But the longer the airways are the more does the warmth of the pit air increase, and its capacity to take up water increases in incomparably greater proportion. This point was confirmed by the experimental investigations as to saturation and temperature of the pit air which were started at the Maybach colliery as a preliminary to the inauguration of the watering system. Two Lamprecht hygrometers were used, and as the readings of the instruments differed slightly a mean between the two readings was taken in each case. The measurements appear to have been regularly continued, and those taken on May 1st, 1894, are selected as a sample:—

No.	Length of the Air-way from the Pit-eye (or Ingate) of the Downcast Shaft up to the Point of Observation.		Temperature in Degrees.		Humidity.		Observations.
					Relative.	Absolute.	
	Metres.	Feet.	Cent.	Fahr.	Per Cent.	Grammes.	
1	50	164	14·5	58	79	9·81	
2	270	885	16·0	60	77	10·48	
3	750	2,460	17·0	62	76	10·97	
4	770	2,525	18·5	65	69	10·93	
5	820	2,689	19·5	67	72	12·08	
6	1,000	3,280	20·0	68	83	14·43	
7	1,030	3,378	22·5	72	84	17·02	
8	1,030	3,378	22·0	71	89	17·24	After watering.
9	1,560	5,117	24·0	75	87	18·87	
10	1,700	5,576	22·0	71	85	17·45	
11	1,750	5,740	24·0	75	84	18·22	
12	1,750	5,740	23·5	74	89	18·57	After watering.
13	1,830	6,002	22·5	72	92	18·65	

When compared with the results obtained before the pit was watered, these figures show very inconsiderable differences. Temperatures are slightly lower, but they are probably attributable to the improved ventilation. There seems indeed to be little ground for the theory that watering would improve the climatic conditions of the pit by cooling the atmosphere, or for the same reason would diminish the risk of fire-damp explosions. The samples of coal-dust taken at various points in the colliery showed 2·05 to 3·65 per cent. of water, but the researches of the Prussian Fire-damp Commission have demonstrated that the explosive properties of coal-dust are not destroyed until it has taken up 50 per cent. of its weight in water. Whence it is concluded that coal-dust remains highly dangerous even in the dampest pit air, and that any attempt to render it harmless, short of systematic and thorough watering, is doomed to failure. For this reason the Körting water-sprayers have been practically abandoned at the Maybach colliery since the introduction of the present method of watering, and are now used only for freshening and cooling the air at certain points in the workings, a purpose to which they are admirably adapted.

* Vol. ix., page 90.

We have seen that the air, in its course through the workings becoming warmer and warmer, takes up more and more water, but at the upcast shaft it cools down, reaches its saturation-point, and deposits a part of the water-vapour in the form of dew. Measurements taken at the upcast shaft of the Maybach colliery on May 21st, 1894, yielded the following results:—

No.	Place of Observation.	Temperature in Degrees.		Humidity.	
				Relative.	Absolute.
		Cent.	Fahr.	Per Cent.	Grammes.
1	Air cross-cut, 32·8 feet from the ventilating shaft ...	25	77	93	21·36
2	Ventilating-shaft, at the suction-inlet of the fan (about 32·8 feet below bank)	19	66	100	16·29
					*5·07

* Decrease in grammes per cubic metre of upcast air.

These measurements were taken at 7 a.m., when there was a temperature above bank of 56·3 degs. Fahr. (13·5 degs. C.). The total quantity of air issuing from the shaft was 123,600 cubic feet (3,500 cubic metres) per minute, and from this it was reckoned that the quantity of water deposited in 24 hours was 902·677 cubic feet (25·56 cubic metres), a calculation confirmed by actual measurement of the water flowing from the upcast shaft. As the flow of water to the underground pumping-engines amounts to about 10,594·8 cubic feet (300 cubic metres) per 24 hours, the deposit in the upcast is 8·52 per cent. of the total inflow. This quantity becomes probably much greater on a colder day when the upcast air-currents are still more extensively cooled down. O. S E.

UNDERGROUND TEMPERATURE AND MINERAL WATERS.

Sur la température des roches et la nature des eaux des mines de houille profondes. *By* JOSEPH LIBERT. *Annales de la Société Geologique de Belgique*, 1893, *vol. xx., pages* 59-67.

Observations have been made at the Produits colliery, Flénu, Belgium. Owing to recent deepening of the shafts these observations have been carried on to a depth of 3,772 feet.

Taking 82 feet as the depth at which atmospheric variations of temperature cease to have any influence, it is calculated that the rate of increase of temperature given by the experiments is 1 deg. Fahr. for 53·97 feet of vertical depth. This agrees closely with results previously obtained by Mr. Cornet in the same district, which gave 1 deg. Fahr. for 54 feet (only, however, for depths up to 1,679 feet).

Prof. Prestwich's mean from English and Belgian mines was 1 deg. Fahr. for 49·5 feet.

The author does not, however, think that the law of the increase of temperature can be expressed as an arithmetical progression, but that the rate of increase is greater at greater depths. Combining the results obtained here with those from the Grand-Buisson colliery in the same coal-field, the author concludes that the rate of increase down to depths of 2,263 feet is 1 deg. Fahr. for 65 or 69 feet; while for depths from 2,263 down to 3,772 feet it is 1 deg. Fahr. for 43 feet.

The spring of water met with at the depth of 3,772 feet has a remarkable chemical composition. It contains about 4 ounces of solid matter per gallon, or more than eight times that of the ordinary waste-waters from the collieries of the district. Chlorides (of which that of sodium is by far the most abundant) form nearly three-quarters of this amount, and sulphate of magnesium amounts to nearly one quarter. G. W. B.

THE TIN-MINING DISTRICT OF ALTENBERG-GRAUPEN (SAXONY).

Der Altenberg-Graupener Zinnerzlagerstättendistrict. By KARL DALMER. *Zeitschrift für praktische Geologie*, 1894, *pages* 313-322, *with figures in the text.*

In the district north of Teplitz the Archæan rocks of the Erzgebirge are cut by a complex of eruptives striking north-west and south-east. These comprise quartz-porphyries, granite-porphyries, and albite-granites, which welled out from fissures coincident with great fault-lines. There is cumulative evidence to show that the granite is the youngest member of the eruptive series, and it is certainly of post-Carboniferous age.

The stanniferous deposits are intimately associated with the granite, being found partly in that rock, and partly in the porphyries around it. Their mode of occurrence in "impregnation-fissures" recalls that of the Cornish tin-ores. In the granite itself they are usually observed near the contact with the older crystalline rocks (gneiss, etc.), so that over the granite bosses an external ore-bearing mantle, so to say, is spread; while deeper down, the granite becomes poor in ore or altogether barren. This is well shown, both in the Altenberg stockwork and in the Zinnwald mines.

The Schellerhan massif, which is the poorest in ore of any granite-mass in the district, is probably the most deeply eroded of any, and it seems not unlikely that at one time tin-ore deposits were present in the higher portions of the mass, which have since been crumbled down and swept away by the agency of water. It was, however, mentioned above that the stanniferous lodes are by no means confined to the granite itself. The granite-bosses, whatever may be the character of the neighbouring rocks, are surrounded by broad "zones of impregnation," and these extra-granitic zones are really the most important from the miner's point of view. This leads up to the hypothesis that the tin-ore deposits were formed by the uprise of metallic vapours from the granite-magma during the process of its gradual consolidation.

The lodes in the district have a very variable strike, although the east-and-west direction predominates, and they generally have a steep dip. Special attention, however, is directed to the Zinnwald "seams," as they are locally termed: these form a complex mass whose shape may be compared with that of a series of flattish up-turned dishes. The "seams" consist chiefly of quartz and lithia-mica, with which, as a rule, are associated tinstone, wolfram, and fluorspar, topaz being of much rarer occurrence. The granite "country" on either side is usually altered into greisen. A good many steeply-dipping lodes, striking north-east and south-west, and containing the same minerals also occur in the Zinnwald area. They are evidently of contemporaneous origin with the "seams."

The question of the dynamic origin of the fissures is dealt with, and the contact-metamorphism of the rocks, spreading from the tin-bearing lodes outwards, is fully described. As in so many other tin-mining districts, it will be noted that here the ore is associated with minerals containing fluor. Prof. Daubrée long ago suggested that tinstone was formed from the reactions of gaseous fluor-compounds; and now another element of the same group, which, under suitable conditions, forms volatile

compounds with tin, namely chlorine, is shown to occur in the micas of Zinnwald, Altenberg, and Graupen. The author is inclined to think that, however little of it may now be left in the deposits, chlorine played an important part in their formation.

The author then proceeds to consider the relations between the tin ores and the blende-bearing lead ores of the district. Some of the stanniferous lodes which are known to occur here and there outside, but near the "impregnation-zones," contain among the associated minerals galena, arsenical and copper pyrites, and malachite. The tin-lodes of the Graupen zone are said to pass gradually south-eastward into pyrites-veins. Other similar associations and passages from one kind of lode into another near Sadisdorf, Lerchenhübel, etc., are described in detail. The conclusion is drawn that the blende-bearing lead ores, much as the tin-lodes, are in causal connexion with the granite-outbursts, but that the conditions which originated the plumbiferous deposits acted at a greater distance from the deep seated granite-magma than those which originated the stanniferous deposits.

O. S. E.

TIN-ORE IN THE MALAY PENINSULA.

Das Zinnerz und seine Gewinnung auf der Halbinsel Malacca. By CARL CRAMER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1894, *vol. xlii., pages 543-545, and Plate XX.*

Up to the present, the tin-ore has only been found as a secondary deposit in recent and also in dried-up river valleys, in layers of pebble-gravel which are capped by bands of blue or red clay, loam, and sand, more rarely by pure kaolin. The thickness of the ore-bearing layer, known as *karang*, varies between a fraction of an inch and 3½ feet. That of the overlying beds is indefinite, and may reach as much as 33 feet, although the average thickness is 6½ to 10 feet. The proportion of tin-ore in the *karang* varies up to 15 per cent., but the layer is at times completely barren for considerable distances. Under ordinary conditions it pays to work *karang* with as little as 0·5 per cent. of good ore, because the cost of mining is so small. The workings are all opencast, no expenditure is needed for blasting-materials and timbering, and the ore can be got out cheaply.

Stream tin-ore is also found in the beds of the larger rivers, and can be proved along the whole sea-coast to some distance out at sea. A French company attempted lately to dredge the ore from the river-bed of the Muar, but the work was abandoned as unprofitable.

The higher one goes up the valleys, the purer and the coarser-grained is the tin-ore: sometimes masses as big as a man's head occur. The highest-grade ore contains about 76 per cent. of tin-oxide, the lowest-grade ore about 45 per cent. The chemical impurities consist mainly of iron, wolfram, and titanium. Moreover, mechanically associated with the ore are titanite and magnetite, wolframite and arsenical pyrites; all these metalliferous compounds affect injuriously the smelting of the ore, making the metal hard and brittle.

The stream-tin is washed by skilful Chinese labourers—scarcely any Malays being employed at the washings—in simple wooden troughs. The erection of plant in the European style would not be advisable, because the small valleys soon get worked out, and the necessity of repeatedly taking up plant and putting it down again would make the expenditure too burdensome. The production as a rule is 77·15 lbs. of tin-ore per head per month. The Chinese at one time smelted the ore themselves, but they now sell it according to sample, taking as a standard 70 per cent. of metallic tin.

O. S. E.

VULCAN TIN-MINE, IRVINEBANK, QUEENSLAND.

ANON. *Australian Mining Standard*, 1895, *vol. xi.*, *page* 524.

The Vulcan tin-mine is the most productive in the north. Since operations were started in 1890, no less than 15,020 tons of stone have been crushed, which yielded 2,357 tons of black tin (*i.e.*, tin ore roasted and treated so as to separate foreign bodies), worth £65,784. During the last half-year 2,272 tons of ore were crushed, giving 397 tons of black tin.

The tin deposit is bunchy, and rich strikes are frequently made. At the 100 feet level a bunch was taken out which measured 70 feet long, 25 feet wide, and 12 feet deep; this being the largest met with so far. It averaged all through 17·5 per cent. of black tin. A second bunch of similar size is now being mined.

J. W.

TUNGSTEN.

The Increasing Demand for Tungsten Ores. ANON. *Engineering and Mining Journal* (*New York*), 1892, *vol. liii.*, *page* 395.

The use of tungsten in the manufacture of tungsten steel has created a very considerable demand for wolfram, the principal ore of that metal, and the supply being limited, its market price has risen to a higher figure than has been obtained for many years. It would appear from recent experiments that the advantages of tungsten steel will prove so important that this alloy will come into quite general use, perhaps taking the place of nickel steel. In view of the high value of tungsten at the present time it is worth the while of prospectors to look for its ores.

J. W.

FENCES OR GATES FOR ENTRANCES TO SHAFTS.

Note sur les Appareils de fermeture de Recettes employés dans les Mines du Pas-de-Calais. *By* MESSRS. FEVRE & WEISS. *Annales des Mines*, 1895, *series* 9, *vol. vii.*, *pages* 515-527, *and* 3 *plates.*

The Ministerial Circular of May 2nd, 1892, required all colliery owners to furnish, within two years, all entrances to shafts with movable barriers capable of preventing the fall of men and materials, and so constructed that the closing of the barrier was assured except when the cage was at the entrance.

The authors describe the methods adopted at several collieries in order to comply with the Ministerial Circular, but it is not practicable to give an intelligible account of them without drawings.

W. N. A.

ALKALINE WATERS FROM COAL-MINES.

Sels alcalins dans les eaux de charbonnages. *By* L. L. DE KONINCK. *Annales de la Société Géologique de Belgique*, 1892, *vol. xx.*, *pages* 69-74.

The author draws attention to the fact that the waters from many collieries of Belgium and Westphalia contain a considerable quantity of bi-carbonate of sodium. The existence of alkaline waters in Palæozoic rocks is intimately connected with that of coal, although the waters from some mines are not alkaline. Various theories have been brought forward to account for the association, but after examination the author dismisses them all as insufficient. No explanation, however, is brought forward to replace them.

G. W. B.

THE PELZER AIR-BRATTICE.

Fr. Pelzer's Wetterscheider. Berg- und Hüttenmännische Zeitung, 1895, *vol. liv., page* 201.

Mr. Pelzer proposes in lieu of small ventilating-shafts to construct larger ones, and employ a portion of same for the air-supply, the remainder being used for transport and other purposes. Such a shaft of 200 to 300 square feet in cross-section will leave sufficient room for ventilating purposes, after providing for a ladder-way and pumping-pit. The objection raised against this plan, on account of the risk of destruction run by the brattice in case of an explosion near the shaft, is not considered an important one, as the repairs would be easily effected. Finally, the leakage to which brattices are liable, especially at the junction with the wall of the shaft, is prevented by the Pelzer method of construction.

The boards, for a timbered shaft, consist of a double set of planks, of which both the horizontal and vertical joints are alternated. Between them is placed a stout cloth of hemp, jute, cotton, etc., dressed with a stiff composition, preferably made of dry powdered alumina and a wood-preserving liquid such as oil, tar, glycerine, etc. The edges of the cloth are left projecting some 27 to 30 inches at the sides of the partition and are laid against the wall timbers, doubled over at the end, and fastened by screws and fillets on to angle-iron brackets screwed to the cross-timbers. The wall planks are filled where the cloth comes in contact with them by lime or cement. C. S.

THE MORTIER DIAMETRICAL VENTILATOR.

Ventilateur diamétral Mortier. By — MORTIER. *Comptes-Rendus Mensuels des Réunions de la Société de l'Industrie Minérale*, 1892, *pages* 134-137.

The Mortier diametrical ventilator consists of a wheel of curved vanes placed on a central disc. The diameter of the spaces between the vanes is equal to 0·7 of the total diameter. The width of the vanes parallel to the axis is about two-thirds of the diameter. The blades, of arc-shape, are placed backwards at an angle of about 40 degs. to the tangent of the circumference. The fan turns in a circular box, whose side-plates are traversed by the axis of the fan, and whose cylindrical surface is provided with two rectangular orifices: one, the largest, is the inlet, and the smaller is the outlet for the air. The centres of the two orifices are placed at the extremities of the same diameter, but the outlet-orifice is prolonged by an expanding chimney, in order to utilize the *vis viva* of the air. Experiments have shown that this ventilator gives its maximum efficiency when the air enters between the blades at a velocity equal to 0·66 of the circumferential velocity. It is stated that the initial manometric efficiency is 0·775.

In order that the entry of air may be effected without shock, it should be guided towards the circumference of the air at a forward angle of about 20 degs., and under these conditions the relative velocity of entry between the blades is almost equal to that of the circumferential velocity; and after entry between the blades the air passes into the central part of the fan and passes again towards the blades, but from the inner side.

In order that the air may traverse the centre of the fan, it must be separated from the inert portion of the blades by means of two oval shutters, which are placed at one side of the axis and on opposite sides of the central disc of the fan.

These external shutters prevent the re-entrance of air and maintain the initial depression or water-gauge produced by the fan due to the tangential velocity. In the absence of the oval shutters the fan does not work so efficiently, but it can then be run in either direction—as a blowing or exhausting fan.

A Mortier diametrical fan has been erected at the Perronnière colliery. It is driven by a steam engine with Rieder valve-gear, and the cylinders are 19·7 inches in diameter, with 13·8 inches stroke. The fan is 55·1 inches in diameter, and the following are the results of experiments, reduced to a velocity of 360 revolutions of the ventilator per minute, and a theoretical water-gauge of 3·096 inches:—

No. of Experiment.	1.	2.	3.	4.	5.	6.	7.
Volume of air, cubic feet per minute ...	36,360	44,520	48,760	52,470	57,980	64,450	72,940
Water-gauge, inches ...	2·573	2·898	2·992	2·819	2·210	2·053	1·949
Horse-power in the air	14·81	20·81	21·70	23·41	20·26	20·94	22·44
Indicated horse-power of engine	37·87	42·87	45·37	52·04	53·48	67·48	68·26
Mechanical efficiency ...	39·1	48·5	50·6	45·0	37·7	31·0	32·9

M. W. B.

THE CAPELL VENTILATING FAN AT THE HOLLAND PIT, WESTPHALIA.

Untersuchung eines grossen Capell-Gruben-Ventilators auf Zeche Holland, bei Wattenscheid in Westphalen. Glückauf, 1894, *vol. xxx., pages* 834-837, *and* 4 *figures.*

A Capell ventilator was erected in 1892 at the Holland pit. The fan has a diameter of 12·8 feet (3·8 metres), and a breadth of 5·9 feet (1·8 metres), and the ventilator has orifices at each side, each of a diameter of 6·2 feet (1·9 metres). The central disc consists of a thick iron-plate, and on either side are riveted 6 inner and 6 outer vanes, set opposite to one another in the manner peculiar to the build of the apparatus.

The spiral casing which surrounds the fan-wheel is built up of masonry and roofed with steel-plates, while the expanding chimney or outlet is made of steel-plate. The bearings of the fan-shaft are lubricated with tallow. By means of small water-taps arranged just above, a feeble streamlet of water trickles on to the grease, and thus a very reliable and economical method of lubrication is contrived.

The ventilator is driven by 8 hempen ropes, each 1¾ inches (45 millimetres) in diameter, running on a rope-drum 3·6 feet (1·1 metres) in diameter. The fly-wheel of the driving-engine is 18·0 feet (5·5 metres) in diameter. The engine has 2 cylinders, each 20·5 inches (0·52 metre) in diameter, and 31½ inches (0·8 metre) stroke, fitted with Rider piston-valves.

The following experiments upon the ventilator were made on April 11th, 1894, by Prof. G. Herbst.

Five anemometers were used at once, placed on a horizontal bar at distances about 2 feet (0·6 metre) apart, with the two outermost instruments about 10 inches (0·25 metre) from the side walls. The bar was fixed consecutively at three different heights, and thus 15 measurements were obtained in each series of experiments. The results of the calculations and experimental data are tabulated below:—

Experiment No.	I.	II.	III.	IV.
1. Revolutions of the engine, per minute	36	53	56·5	60
2. Revolutions of the fan, per minute ...	180	259	375·0	282
3. Gearing ... ... 1 :	5	4·887	4·867	4·70
4. Water-gauge, millimetres	80	174	193	222
5. Water-gauge, inches ..	3·150	6·850	7·598	8·740
6. Volume of air per minute, cubic metres	2,498·0	3,922·8	4,294·4	4,600·0
7. Volume of air per minute, cubic feet	88,220	138,547	151,650	162,450
8. Weight of 1 cubic metre of the air, kilogrammes	1·1995	1·1884	1·1862	.....
9. Weight of 1 cubic foot of the air, pounds... ...	0·0749	0·0742	0·0740	.....
10. Mean steam pressure, kilogrammes per square metre	1·2467	2·9875	3·1188	.....
11. Mean steam pressure, pounds per square inch	17·73	42·49	44·36	.....
12. Indicated horse-power ...	66·45	234·42	260·89	.....
13. Work in the air, horse-power	44·28	150·76	182·94	.....
14. Work in the incoming air, horse-power ...	1·18	4·53	5·94	.....
15. Total efficiency of the ventilator, horse-power	43·10	146·23	177·00	.....
16. Useful effect of the fan, per cent....	64·9	62·4	67·8	.....

M. W. B. and O. S. E.

THE SCHNEIDEMÜHL SPRINGS, GERMANY.

Der gefährliche Brunnen zu Schneidemühl in Westpreussen. *By* H. Becker. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1893, *vol. xli., page* 432.

For some time past the town of Schneidemühl in West Prussia has been exposed to serious danger from a spring of water which has overflowed and threatens to undermine the town. Schneidemühl lies on the edge of the great geological fault forming the valleys of the Warta and the Netze, stretching from Küstrin on the Oder to Bromberg on the Vistula for a distance of 60 to 90 miles, with a breadth of 3 to 6 miles. The level of this district is low, and it is broken only by the ridge of the Stargard watershed, a slight elevation running parallel to the Warta-Netze fault, which parts the waters falling into the Baltic from those running into the river Netze, a tributary of the Warta and Oder rivers. The watershed is dotted over with numerous small lakes discharging through these streams. A small river called the Küddow takes its rise in the lakes and runs south into the Netze river, and the town of Schneidemühl stands at the junction of the two streams. The land was formerly under the sea, which deposited the sand and clay forming the present soil. The Stargard ridge alone is of Chalk, and rests on a volcanic foundation.

It was here in 1892, that the municipality of Schneidemühl determined to sink an artesian well. A pipe 8 inches in diameter was driven down, first through a stratum 29·5 feet thick of sand and gravel, then through 164 feet of soft clay, lastly through 42·6 feet of fine sand. At a depth of 236 feet, muddy water mixed with

clay and sand sprang to the surface. The opening being closed, the water found its way out at the sides, and then burst through the pipe to a height of about 20 to 30 feet. All the neighbouring streets were flooded, the houses undermined, and the pavements lifted by the force of the water. Fissures appeared, from 20 to 30 houses fell in, and many others were threatened.

To avert the danger, the town authorities determined to sink a shaft about 10 feet in diameter round the pipe, carry it 29 feet down to the bed of clay, and thus stem the torrent. It was assumed that the water formed the subterranean outflow of one of the lakes in which the river Küddow takes its rise. But the pressure of the superimposed shaft was not strong enough to counteract the force of the spring. In 24 hours 105,930 cubic feet of water were thrown up, with 7,062 cubic feet of heavy clay and sand; and as it had taken a week to sink the shaft to a depth of about 5 feet the attempt was necessarily abandoned.

Mr. Beyer, a mining engineer from Berlin, next suggested that a second pipe should be introduced into the mouth of the first, and carried up above the ground to a height sufficient to overcome the pressure of the water. He considered that the spring was an artesian well so-called, that is a subterranean watercourse, and that the pressure necessary to bring the water to the surface acted somewhat after the manner of a lever. The lake with which the spring was connected lay at the end of the upper and higher arm of the lever; the spring at the extremity of the shorter and lower arm. According to this theory, the spring having once been tapped, the water in the pipe would rise till it reached the level of the lake, and if it were possible to elevate the pipe to such a height as to bring it on a level with the lake, the flow would be checked. It was accordingly raised 65·6 feet above the ground, and for a time the rush of water was successfully combated. In spite, however, of this systematic damming the water broke out again in less than a month at the side of the pipe, and began to undermine the neighbouring houses. Everything seemed to point to a second flood, as disastrous as the first, and it became evident that the only way to put an end to the mischief was to discover the cause and apply a radical remedy.

The author is of opinion that this has not yet been done, nor the origin of the eruption of water explained. The lake is 60 miles away, and cannot affect the spring to the extent supposed. Having regard also to the material brought up, which is entirely sand, he has come to the conclusion that it must be connected with the ancient ocean bed, lying more than 3,000 feet below the level of the lowlands of West Prussia. The whole of the geological formation, from the Pomeranian coast to the valley of the Netze, consists of sand, clay, and water-worn pebbles covering this old sea bed. In so vast a region a small lake would be lost. The only way of solving the problem of the overflow of the Schneidemühl spring is to compare its action with that of other springs in different parts of Germany. In the district round Frankfort borings for water have in three separate places reached the beds of the old Rhine and Main lakes. From the character of the strata pierced, which is similar to that in the valley of the Netze, he infers that the spring at Schneidemühl is not an outlet from any subterannean stream or lake. The water comes from the ocean-bed itself, and the high pressure at which it rises to the surface is due to the presence in it of large volumes of gases. A spring at Nauheim, in the Rhine district, when chemically analysed, was found to consist of 2 volumes of carbonic acid gas and 1 volume of water, compressed to one-third its original volume, and hence the water, when liberated, burst forth with great velocity, rising to a height of 90 feet.

The author considers that the only way of stemming the torrent of the Schneidemühl spring effectually is to make other boreholes in the vicinity, and

thus to relieve the pressure of the gases. To dam up the flow, as has been already attempted, can only cause explosive outbursts elsewhere. If the other boreholes are carefully sunk within a given radius, the gases will be set free as soon as the clay strata is penetrated, and the volume of water in the main spring reduced within proper limits. As soon as the pressure of the gases is relieved, the ground will settle and all danger of falling-in be averted. It is not because great masses of sand are brought up that the houses totter and fall, but because the ground itself, the bed of sand on which the houses rest, is undermined. A thickness of 29 feet of sand is not sufficiently stable to make a firm foundation. The danger to Schneidemühl is caused by the water rising up through and flowing over the clay, and the town will not be safe until, by sinking other wells to act as safety-valves, and carry off the gases, the spring has again been reduced to its old level.

B. D.

WOLFRAM IN THE SIERRA DE CÓRDOBA, ARGENTINE REPUBLIC.

Die Wolfram-Minen der Sierra von Córdoba in der Argentinischen Republik. By Prof. Bodenbender. *Zeitschrift für praktische Geologie*, 1894, *pages* 409-414.

Wolfram, in the Argentine Republic, was first discovered by Mr. Avé-Lallemand in the Sierra de San Luis, then Dr. Brackebusch found the mineral in the Sierra de Çórdoba, and in 1891 the present author analysed specimens from another locality in the southern portion of that sierra, showing an average of 74·86 per cent. of tungstic oxide.

The mines lie near the crest of the sierra, some 20 miles west of Sauce, in the department of Calamuchita, at a height of about 5,900 feet above sea-level. They are worked by a German firm of Rosario de Santa Fé. The system of Archæan rocks, to which nearly the whole Sierra de Córdoba belongs, consists chiefly in this eastern portion of grey fibrous gneiss, succeeded westward by hornblende-schists alternating with mica-schists and gneisses, while the crest of the sierra is made up of a granite which varies from fine to coarse-grained and porphyritic. Pegmatite and quartz-veins, the latter forming now ribs now hillocks, continually crop out on the climb from Sauce to the mines.

Of the four mines which the author describes, the most important is the San Virgilio, where the wolfram was first found. The hanging wall here is Archæan gneiss, separated from a thick quartz-vein by a salband of mica. There is no salband at the footwall, which is also gneiss, but includes several varieties of the rock, and shows much streakiness (brecciation). The vein-stuff is, of course, mainly quartz, with which are associated nests of wolfram, some of these averaging 18 cubic feet in capacity. It may be remarked that the wolfram here also occurs in direct association with the gneiss, with apatite, mica, copper sulphides and oxides, and molybdenite.

At the Fischer mine, in the fork between the arroyos Aspero and Rodeo de los Caballos, several parallel quartz-veins from 3 feet down to a few inches thick, range with the same strike and dip as the hornblende-schists and gneiss. The wolfram-bearing lode is 3½ to 6½ feet thick, is very porous at the hanging wall, and has inclusions of brown and ochreous-red hæmatite. Copper and iron pyrites also occur. The lode dips very slightly in comparison with the outcrops of the neighbouring rocks, and some of the hornblende-schists and gneisses dip westward instead of (as usual) eastward. This disturbance is attributable to an outburst of granite south of the mine, which sends out apophyses into the schists and has also something to do with the quartzite-boss of Cerrito Blanco, 197 feet in diameter; this latter is probably a local swelling of the quartz-veins.

Quite a different type of lode is found at the Santo Tómas mine, some 5 miles west of the San Virgilio, and close to the crest of the sierra. Here quartz-veins of very variable thickness (maximum 19 or 20 inches) strike north-north-west and south-south-east through red and white felspar-granites, from which they are generally marked off by a salband of mica. A trial-digging, 5 feet or so deep, showed that comparatively little wolfram is present, and it is probable that the mine will be abandoned. The great inflow of water, on this plateau-like boggy ridge, will, in any case, constitute a serious obstacle to mining operations.

At the Santa Barbara mine may be seen the intermediate type, between the streaky (brecciated) veins of the Archæan system and the veins in the granite. Work at this mine is now suspended.

The author concludes that the outburst of granite in this area was preceded, in post-Archæan and pre-Rhætic times, by the formation of a great system in fissures, dislocating the rocks, causing upheaval in one place and subsidence of another. Into the interstices thus created poured the molten minerals which gave rise to the wolfram-quartz lodes of the streaky (brecciated) type; these belong, therefore, to the group of dislocation-lodes. The veins within the granite itself are the result of aqueous solutions filling up the fissures which were brought about by contraction of the rock on cooling.

Except at San Virgilio, where a shaft 82 feet deep has been sunk through the hanging wall, and a heading 130 feet or so long has been driven to the footwall, the workings at the mines consist of mere trial-trenches, at most 7 feet deep. Any methods other than the most primitive will probably not obtain for some time to come in this area. Capital and technical skill are wanting, and the difficulties of transport are considerable. From a height of 6,000 or 7,000 feet the ores are carried down on muleback by all but impassable paths in one day to Sauce, thence 36 hours by waggon takes them to the railway-station at Rio Cuarto. Moreover, the dearth of fuel is serious, the only wood in the district coming from sparse growths of *tabaquillo* (*Polylepis racemosa*). O. S. E.

PURIFICATION OF BOILER FEED-WATERS.

By Dr. Francis Wyatt. *Engineering and Mining Journal* [*New York*], 1895, *vol. lx., page* 220.

After describing the use of burnt lime for removing temporary hardness (due to bicarbonates of lime and magnesia), also the use of sodium carbonate or hydrate, for removal of permanent hardness, Dr. Wyatt describes the use of newer chemicals, notably bichromate of soda. When it is necessary to treat the water within the boilers themselves, the use of caustic alkalies is not advised. These may then be replaced with advantage by sodic tannate, sodic triphosphate, or sodic bichromate, all of which have a specific chemical action. Sodic tannate forms soluble calcic or magnesic tannates, and soluble sulphates or chlorides of sodium.

Tri-sodic phosphate gives soluble sulphates, and fine and granular precipitates of calcic and magnesic phosphates, which do not adhere to the boiler-plates, and are readily and easily blown off. Sodic bichromate produces equally fine and granular precipitates of calcic and magnesic chromates, as well as soluble sulphates, the following being the equations:—

(1) $CaH_2(CO_3)_2 + Na_2Cr_2O_7 = CaCrO_4 + Na_2CrO_4 + 2CO_2 + H_2O.$

(2) $CaSO_4 + Na_2Cr_2O_7 = CaCrO_4 + Na_2SO_4 + CrO_3.$

(3) $MgSO_4 + Na_2Cr_2O_7 = MgCrO_4 + Na_2SO_4 + CrO.$

This use of bichromate of soda in very slight excess is new to most steam raisers. It was long supposed that the calcic or magnesic chromates, formed as above, would be again decomposed into sulphate or carbonate by the alkaline soda salts in solution, this idea being based upon what takes place in boiling solutions in open vessels. At high pressures, however, experiments have demonstrated that the action is reversed, and that the earthy chromates are undoubtedly all deposited and very readily removed by blowing off. The use of bichromates in the proportion of 2¾ ounces for every part per 100,000 of permanent hardness in 1,000 gallons of water, has the additional advantage, over all other scale-preventers, of furnishing perfectly neutral steam, and chemically pure distilled water. J. W.

PELTON WATER-WHEEL.

Report of the Committee on Science and the Arts. Journal of the Franklin Institute, Philadelphia, 1895, *vol. cxl., pages* 161-197. *With* 27 *illustrations.*

Their report may be summed up in the conclusion reached, that the Pelton water-wheel possesses all the advantages of simplicity of construction, economy of installation and maintenance, adaptability to extreme heads of water, of transportability, of close and sensitive automatic regulation, and of high speeds, which belong to other water-wheels of its class which have preceded it; but that in point of efficiency it has excelled all others. J. W.

PACKING OF COAL-SEAMS IN BOHEMIA.

Der Versatzabbau des Gaskohlenflötzes zu Unter-Reichenau (Nordwest Böhmen). By Anton Frieser. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen,* 1895, *vol. xliii., pages* 253-255, *and figure.*

The gas coal-seam which forms part of the Falkenau brown-coal-field yields a renowned gas coal, and the system of packing the excavations has been in operation for almost forty years.

The coal-seam occurs at a depth of from 60 to 200 feet below the surface in two layers of some 8 feet in thickness, divided by a band of clay, or in some places of coarse coal, the lower coal being broken by numerous fissures and very gassy, while the top coal is columnar in structure and of smaller fracture though brighter appearance than the bottom coal.

The lower seam is worked first, but the methods of mining and packing are the same in both cases. The pillars, 40 feet square, are crossed by a gallery, reducing their width to 16 feet, and the remainder is worked in five cross-lifts each 8 feet wide. The space thus cleared is then tightly filled with stone, and the operation continued with other portions of the pillar till the whole has been wrought and packed, the gallery and cross-galleries being likewise filled up. The workings are timbered, the roof being supported by piles and props, and almost all the timber has to be abandoned.

The packing stone is obtained by sinking shafts from the surface, and these are continued down into part of the workings to facilitate delivery of the supply.

Above the gas-coal, a seam of brown coal up to 105 feet in thickness is found, especially in the north-western portion of the coal-field. In the Reichenau district, this brown coal is only covered by a slight layer of gravel, and is very wet from the immediate proximity of the river Eger, so where this seam overlies the gas-coal the goaf has to be puddled with a mixture of sand, ballast, and ashes to prevent the breaking-down of the roof and the admission of water.

As the workings are completely packed, there is practically no coal lost, and pit-fires never occur. Although expensive the process is economical, since all the valuable gas-coal is wrought and the water kept out of the workings; moreover subsidences of the upper surface are minimized, varying between 2 and 3 feet according to the depth of seam, and where puddled packing is used these figures are greatly reduced. The pressure of the roof compresses one volume of ordinary stone-and-sand packing down to 0·6, clay down to 0·5, and puddled sand and ashes only to 0·8 or 0·9. C. S.

ZINC-BLENDE MINING NEAR WEBB CITY, MISSOURI, U.S.A.

By CARL HEINRICH. *Engineering and Mining Journal* (*New York*), 1892, *vol. liii., pages* 594-595, *with* 5 *figures.*

The author's object in this paper is to point out the wastefulness of the present method of mining the zinc-blende deposits near Joplin and Webb City in south-western Missouri, and to suggest a more correct and ultimately more economical manner of conducting operations.

This zinc-blende occurs in lenticular deposits in the upper strata of the Sub-Carboniferous limestone. Between the ore and the limestone there is always a deposit of chert or flint, which also assumes a lenticular shape. As most of the deposits are near the surface, the working of them is a comparatively easy matter.

The usual method at Webb City, is for the owner of the soil to lease it to a mining company, who sink trial-shafts and prospect generally. When an ore-deposit is struck, the shaft is sunk only a short distance down, not by any means to the bottom of the deposit. The upper part of the vein is thus drained, and a sufficiency of water is got for the dressing processes. The surface is then let out to individual miners in lots, usually 200 feet square. These miners sink shafts and work out the part drained of water; and, as no supports are used, the lime-stone roof generally caves in, and the lower portions of the ore-deposits are buried and lost.

The rational way of mining these lenticular deposits is illustrated by an ideal section embodying the following suggested improvements:—When a trial-shaft strikes a deposit it should be continued down to a fair distance below the bottom, so that it shall drain the whole of the deposit. The approximate extent and shape of the ore-body should then be ascertained by drifts from the discovery-shaft at various levels. A second and smaller shaft should then be sunk for ventilating purposes at or near the centre of the deposit. The mining should begin at the bottom of the deposit and extend upward in an arch form, so that the roof shall always be able to support itself. Timbering is used for gaining access to the faces. The barren pieces of rock need never be raised out of the working, and the tailings from the dressing processes may be lowered down the air-shaft to fill up the vacant spaces at the bottom of the working underneath the timbering. In this way, after the whole of the ore has been excavated, the space formerly occupied by it will be partly filled up again, so that the roof will be more or less supported. Another advantage will be that the unsightly mounds usually seen round the shaft mouth will be removed, and their weight will not crush down the limestone roof. J. W.

III.—REPORT OF THE CORRESPONDING SOCIETIES COMMITTEE OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. IPSWICH, 1895.*

The Corresponding Societies Committee of the British Association beg leave to submit to the General Committee the following Report of the proceedings of the Conference held at Ipswich.

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The meetings of the Conference were held at the Co-operative Hall, Ipswich, on Thursday, September 12th, and Tuesday, September 17th, at 3·30 p.m.

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At the first Conference (September 12th, 1895) the Corresponding Societies Committee were represented by Prof. R. Meldola, Mr. G. J. Symons, Mr. Hopkinson, and Mr. T. V. Holmes (Secretary).

ADDRESS OF THE CHAIRMAN, MR. G. J. SYMONS, F.R.S.

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3. *Earth Temperature at Shallow and at Great Depths.*—The second half of this subject has often been brought before you, because the Underground Temperature Committee is the oldest one of the British Association. It, as you know, deals chiefly with the temperature in mines and in deep shafts and wells. Any one who can obtain good records at depths of, or exceeding, 1,000 feet can do useful work, but I am doubtful whether much more can be learned in this country by observations at depths between 10 feet and 1,000 feet than we already know. I insert the words, "in this country," because I do not think that the law of decrease for tropical and for Arctic localities is known. Unfortunately we have no representatives of such localities here, or we might sow a productive seed. Observations at shallow depths—say 3 inches to 10 feet—are becoming less rare than they were, and the time is not distant when the law of temperature variation for shallow depths will be known with sufficient accuracy. That much has yet to be ascertained, many persons learned by burst water-pipes last winter. I mention this as an illustration of the application of scientific records to the welfare of mankind, not as an indication that I consider the mischief to have been wholly produced by soil temperature; but I must not digress.

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SECTION C.

Mr. Osmund W. Jeffs, Secretary to the British Association Committee for the Collection and Preservation of Geological Photographs, stated that it had been proposed by the Committee, and adopted by the Council of the British Association, that the photographs collected should be placed in the Museum of Practical Geology, Jermyn Street. The first part of the collection, consisting of 800 photographs, had already been deposited there, and the rest would be handed over as soon as possible. As, however, a great many parts of the British Isles were still unrepresented, it was proposed that they should go on collecting. From some of the eastern counties no photographs whatever had been sent, and on that very day he had been promised some from that neighbourhood. He hoped therefore that the delegates would remember that they were still collecting, and would mention the fact to their respective societies.

Mr. De Rance, after complimenting Mr. Jeffs on the results he had achieved, remarked that it would be a good thing if each society would issue a circular, and send it to other local societies, so that all might know what photographs

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had been taken in each locality and were available, and, on the other hand, in what districts photographers were most needed.

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SECTION G.

Prof. Merivale . . . . wished, before the meeting ended, to say a few words on flameless explosives. The North of England Institute of Mining and Mechanical Engineers had been continuing their experiments, and had published one report. They were still going on with their labours, and another report would be published shortly.

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At the second Conference (September 17th, 1895) the Corresponding Societies Committee was represented by Dr. Garson (in the chair), Mr. Hopkinson, Mr. Symons, and Mr. T. V. Holmes (Secretary).

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SECTION A.

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Mr. Sowerbutts . . . . was afraid that town societies could never do anything in noting earth-tremors on account of the tremors caused by passing trains, waggons, etc. He did not know any spot within 7 miles of Manchester where a recording instrument might safely be placed, unless it were at the bottom of a coal-mine.

The Rev. J. O. Bevan believed that these superficial tremors were of short duration and would not affect the observations made with any properly constructed meteorological instrument. . . .

Mr. White Wallis said . . . . as regards the supposed difficulty of making observations on earth-tremors in towns, he might say that modern instruments were practically unaffected by passing vibrations from railway trains, etc. A tremor of such short duration was not represented on these instruments. They had one in a cellar, but though the vibration of a passing train was felt in the house, it was not recorded by the instrument. The Darwin bifilar pendulum was somewhat expensive; Prof. Milne accomplished the same result in a much simpler way.

The Chairman pointed out that the delegates might understand from what had been said that the whole cost of the needful apparatus would not necessarily exceed from £20 to £25, including the erection of a suitable column on which to place it.

SECTION C.

Mr. A. S. Reid . . . . remarked that Mr. Osmund Jeffs, Secretary to the Geological Photographs Committee, had wished to resign, but had been persuaded to retain the post for another year, Mr. W. W. Watts having consented to act as co-secretary during that time, and afterwards to become sole secretary. Mr. Jeffs, however, would always be glad to forward any photographs which may reach him. The Committee had at one time thought of bringing their work to a conclusion, but had lately felt that it would not be judicious to do so. . . . The Committee were sending out a new circular containing instructions as to the best methods of using the camera, and the best kind of camera to use, together with an abstract of the opinions collected on those subjects.

Mr. Sowerbutts wished delegates to remember that platinotype photographs were the best to send, as those printed by the bromide process often faded very rapidly, while platinotype prints would not.

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COMMITTEES APPOINTED BY THE GENERAL COMMITTEE AT THE IPSWICH MEETING IN SEPTEMBER, 1895.

1.—RECEIVING GRANTS OF MONEY.

Subject for Investigation or Purpose.	Members of the Committee.	Grants.
Seismological observations	*Chairman.*—Mr. G. J. Symons. *Secretaries.*—Mr. C. Davison and Prof. J. Milne. Lord Kelvin, Prof. W. G. Adams, Mr. J. T. Bottomley, Sir F. J. Bramwell, Prof. G. H. Darwin, Mr. Horace Darwin, Mr. G. F. Deacon, Prof. J. A. Ewing, Prof. A. H. Green, Prof. C. G. Knott, Prof. G. A. Lebour, Prof. R. Meldola, Prof. J. Perry, Prof. J. H. Poynting, and Mr. Isaac Roberts.	£ s. d. 80 0 0
To confer with British and foreign societies publishing mathematical and physical papers as to the desirability of securing uniformity in the size of the pages of their Transactions and Proceedings. [Last year's grant renewed.]	*Chairman.*—Prof. S. P. Thompson. *Secretary.*—Mr. J. Swinburne. Mr. G. H. Bryan, Mr. C. V. Burton, Mr. R. T. Glazebrook, Prof. A. W. Rücker, and Dr. G. Johnstone Stoney.	5 0 0
To report on methods of calibrating the measuring instruments used in engineering laboratories, and to take steps for comparing the measuring instruments at present in use in different laboratories [£25 renewed.]	*Chairman.*—Prof. A. B. W. Kennedy. *Secretary.*—Prof. W. C. Unwin.	30 0 0
To consider means by which better practical effect can be given to the introduction of the screw gauge proposed by the Association in 1884.	*Chairman.*—Mr. W. H. Preece. *Secretary.*—Mr. Conrad W. Cooke. Lord Kelvin, Sir F. J. Bramwell, Sir H. Trueman Wood, Maj.-General Webber, Mr. R. E. Crompton, Mr. A. Stroh, Mr. A. Le Neve Foster, Mr. T. P. Hewitt, Mr. G. K. B. Elphinstone, and Mr. T. Buckney.	10 0 0
Corresponding Societies Committee for the preparation of their Report.	*Chairman.*—Prof. R. Meldola. *Secretary.*—Mr. T. V. Holmes. Mr. Francis Galton, Sir Douglas Galton, Sir Rawson Rawson, Mr. G. J. Symons, Dr. J. G. Garson, Sir John Evans, Mr. J. Hopkinson, Prof. T. G. Bonney, Mr. W. Whitaker, Prof. E. B. Poulton, Mr. Cuthbert Peek, and Rev. Canon H. B. Tristram.	30 0 0
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2.—NOT RECEIVING GRANTS OF MONEY.

Subject for Investigation or Purpose.	Members of the Committee.
The rate of increase of underground temperature downwards in various localities of dry land and under water.	*Chairman.*—Prof. J. D. Everett. *Secretary.*—Prof. J. D. Everett. Prof. Lord Kelvin, Mr. G. J. Symons, Sir A. Geikie, Mr. J. Glaisher, Prof. Edward Hull, Prof. J. Prestwich, Dr. C. Le Neve Foster, Prof. A. S. Herschel, Prof. G. A. Lebour, Mr. A. B. Wynne, Mr. W. Galloway, Mr. Joseph Dickinson, Mr. G. F. Deacon, Mr. E. Wethered, Mr. A. Strahan, and Prof. Michie Smith.
The establishment of a national physical laboratory for the more accurate determination of physical constants, and for other quantitative research, and to confer with the Council of the Association.	*Chairman.*—Sir Douglas Galton. *Secretary.*—Prof. O. J. Lodge. Lord Rayleigh, Lord Kelvin, Sir H. E. Roscoe, Prof. A. W. Rücker, Prof. R. B. Clifton, Prof. Carey Foster, Prof. A. Schuster, Prof. W. E. Ayrton, Dr. W. Anderson, Dr. T. E. Thorpe, Mr. Francis Galton, and Mr. R. T. Glazebrook.
To enquire into the proximate chemical constituents of the various kinds of coal.	*Chairman.*—Sir I. Lowthian Bell. *Secretary.*—Prof. P. Phillips Bedson. Prof. F. Clowes, Mr. Ludwig Mond, Profs. Vivian B. Lewes and E. Hull, and Messrs. J. W. Thomas and H. Bauerman.
The collection, preservation, and systematic registration of photographs of geological interest.	*Chairman.*—Prof. J. Geikie. *Secretaries.*—Mr. O. W. Jeffs, and Mr. W. W. Watts. Prof. T. G. Bonney, Prof W. Boyd Dawkins, Prof. T. McKenny Hughes, Dr. T. Anderson, and Messrs. A. S. Reid, E. J. Garwood, W. Gray, H. B. Woodward, J. E. Bedford, R. Kidston, R. H. Tiddeman, J. J. H. Teall, and J. G. Goodchild.
To consider the best methods for the registration of all type specimens of fossils in the British Isles, and to report on the same.	*Chairman.*—Dr. H. Woodward. *Secretary.*—Mr. A. Smith Woodward. Rev. G. F. Whidborne, Mr. R. Kidston, and Mr. J. E. Marr.
To study life zones in the British Carboniferous rocks.	*Chairman.*—Mr. J. E. Marr. *Secretary.*—Mr. E. J. Garwood. Mr. A. H. Foord.
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THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1895–96.

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Bath Natural History and Antiquarian Field Club, 1855	Bath N. H. A. F. C. ..	Rev. W. W. Martin, Royal Literary and Scientific Institution, Bath	100	5s.	10s.	Proceedings, annually.
Belfast Natural History and Philosophical Society, 1821	Belfast N. H. Phil. Soc.	Museum, College Square. R. M. Young, B.A.	268	None	£1 1s.	Report and Proceedings, annually.
Belfast Naturalists' Field Club, 1863..	Belfast Nat. F. C. ..	Museum, College Square. F. J. Bigger, M.R.I.A.	516	5s.	5s.	Report and Proceedings, annually.
Berwickshire Naturalists' Club, 1831..	Berwicksh. Nat. Club ..	Dr. J. Hardy, Old Cambus, Cockburnspath, N.B.	400	10s. 6d.	7s. 6d.	History of the Berwickshire Naturalists' Club, annually.
Birmingham Natural History and Philosophical Society, 1858	Birm. N. H. Phil. Soc.	Walter E. Collinge, Mason College, Birmingham	266	None	£1 1s.	Journal, monthly; Proceedings, annually.
Bristol Naturalists' Society, 1862 ..	Bristol Nat. Soc. ..	H. Percy Leonard, Literary and Philosophic Club, 20, Berkeley Square, Bristol	173	5s.	10s.	Proceedings, annually.
Buchan Field Club, 1887	Buchan F. C.	J. F. Tocher, 5, Chapel Street, Peterhead	160	5s.	5s.	Transactions, annually.
Burton-on-Trent Natural History and Archæological Society, 1876	Burt. N. H. Arch. Soc..	Thomas Gibbs, 30, High Street, Burton-on-Trent	242	None	5s.	Annual Report. Transactions, occasionally.
Caradoc and Severn Valley Field Club, 1893..	Car. & Sev. Vall. F. C...	E. S. Cobbold, 37, Castle Street, Shrewsbury	160	None	5s.	Transactions and Record of Rare Facts, annually.
Cardiff Naturalists' Society, 1867 ..	Cardiff Nat. Soc. ..	Walter Cook, 98, St. Mary Street, Cardiff	459	None	10s. 6d.	Transactions, half-yearly.
Chester Society of Natural Science and Literature, 1871	Chester Soc. Nat. Sci..	Grosvenor Museum, Chester. G. R. Griffith	696	None	5s.	Annual Report. Proceedings, occasionally.
Chesterfield and Midland Counties Institution of Engineers, 1871	Chesterf. Mid. Count. Inst.	Stephenson Memorial Hall. W. F. Howard, 15, Cavendish Street, Chesterfield	350	£1 1s. None	Members, 31s. 6d.; Associates and Students, 20s.	"Transactions of The Federated Institution of Mining Engineers," about every two months.
Cornwall, Mining Association and Institute of, 1859	Cornw. Min. Assoc. Inst.	William Thomas, C.E., F.G.S., Penelvan, Camborne	341	10s. 6d.	Minimum, 10s. 6d.	Transactions, annually.
Cornwall, Royal Geological Society of, 1814	Cornw. R. Geol. Soc. ..	G. B. Millett, Penzance..	92 Membs. 14 Associates	None	£1 1s.	Report and Transactions, annually.
Croydon Microscopical and Natural History Club, 1870	Croydon M. N. H. C. ..	Public Hall, Croydon. R. F. Grundy	242	None	10s.	Proceedings and Transactions, annually.
Dorset Natural History and Antiquarian Field Club, 1875	Dorset N. H. A. F. C. ..	N. M. Richardson, Montevideo, Chickerel, Weymouth	333	None	10s.	Proceedings, annually.
Dumfriesshire and Galloway Natural History and Antiquarian Society, 1862	Dum. Gal. N. H. A. Soc.	Dr. E. J. Chinnock, Grey Friars', Dumfries	174	2s. 6d.	5s.	Transactions and Journal of Proceedings, annually.
East Kent Natural History Society, 1857	E. Kent N. H. Soc. ..	19, Watling Street, Canterbury. Stephen Horsley	76	None	10s. 6d.	"South Eastern Naturalist," occasionally.
East of Scotland Union of Naturalists' Societies, 1884	E. Scot. Union	William D. Sang, 28, Whyte's Causeway, Kirkcaldy, N.B	10 Societies 950 Membs.	None	Assessment of 4d. per member	Proceedings, occasionally.
Edinburgh Geological Society, 1834..	Edinb. Geol. Soc. ..	H. M. Cadell, B.Sc., 5, St. Andrew Square, Edinburgh	140	10s. 6d.	12s. 6d.	Transactions, annually.
Essex Field Club, 1880	Essex F. C.	William Cole, 7, Knighton Villas, Buckhurst Hill, Essex	400	10s. 6d.	15s.	"Essex Naturalist," monthly.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1895-96.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Federated Institution of Mining Engineers	Fed. Inst. Min. Eng. ..	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne	2,300	None	None	Transactions, about every two months.
Glasgow Archæological Society, 1856	Glasgow Arch. Soc. ..	207, Bath Street, Glasgow, J. Dalrymple Duncan and W. G. Black	343	None	12s. 6d.	Transactions, annually.
Glasgow, Geological Society of, 1858	Glasgow Geol. Soc. ..	J. B. Murdoch, Capelrig, Mearns, Glasgow	250	None	10s.	Transactions, annually.
Glasgow, Natural History Society of, 1851	Glasgow N. H. Soc. ..	R. S. Wishart, M.A., and John Cairns, Jun., 207, Bath Street, Glasgow	320	7s. 6d.	7s. 6d.	Proceedings and Transactions, annually.
Glasgow, Philosophical Society of, 1802	Glasgow Phil. Soc. ..	John Mayer, 207, Bath Street, Glasgow	640	£1 1s.	£1 1s.	Proceedings, annually; occasional papers.
Hampshire Field Club, 1885	Hants. F. C.	Hartley Institution, Southampton. W. Dale, F.G.S.	250	None	7s. 6d.	Proceedings, annually.
Hertfordshire Natural History Society and Field Club, 1875	Herts. N. H. Soc. ..	John Hopkinson, F.L.S., The Grange, St. Albans	260	10s.	10s.	Transactions, quarterly.
Holmesdale Natural History Club, 1857	Holmesdale N. H. C. ..	A. J. Croefield, Carr End, Reigate	88	10s.	10s.	Proceedings, every two or three years.
Inverness Scientific Society and Field Club, 1875	Inverness Sci. Soc. ..	J. Moran, Free Library Buildings, Inverness	180	5s.	5s.	Transactions, occasionally.
Ireland, Statistical and Social Inquiry Society of, 1847	Stat. Soc. Ireland ..	W. Lawson, 35, Molesworth Street, Dublin	100	None	£1.	Journal, annually.
Leeds Geological Association, 1874 ..	Leeds Geol. Assoc. ..	Mechanics' Institution. J. H. Howarth, F.G.S.	129	None	5s., 2s. 6d., 1s.	Transactions, annually.
Leeds Naturalists' Club and Scientific Association, 1868	Leeds Nat. C. Sci. Assoc.	H. B. Wilson, Westfield, Armley, Leeds	171	None	6s.	Transactions, occasionally.
Leicester Literary and Philosophical Society, 1835	Leicester Lit. Phil. Soc.	J. M. Gimson, Town Museum, Leicester	313 Members & Associates.	None	Members, £1 1s.; Associates, 10s. 6d.	Transactions, quarterly.
Liverpool Engineering Society, 1875..	Liv'pool E. Soc.	R. C. F. Annett, Royal Institution, Liverpool	274	None	Resident, £1 1s.; Non-res., and Students, 10s. 6d.	Transactions, annually.
Liverpool Geological Society, 1858 ..	Liv'pool Geol. Soc. ..	Royal Institution. H. C. Beasley	50	None	£1 1s.	Proceedings, annually.
Liverpool, Literary and Philosophical Society of, 1812	Liv'pool Lit. Phil. Soc...	Royal Institution. J. M. McMaster	284	None	£1 1s. Ladies, 10s. 6d.	Proceedings, annually.
Liverpool Microscopical Society, 1868	Liv'pool Mic. Soc. ..	Royal Institution. Andrew T. Smith, jun.	91	10s. 6d.	10s. 6d.	Report, annually; papers occasionally.
Malton Field Naturalists' and Scientific Society, 1879	Malton F. N. Sci. Soc...	Museum, Yorkersgate, Malton, Yorkshire. Rev. S. Jenkinson	100	None	2s. 6d.	Naturalists' Notes, monthly.
Man, Isle of, Natural History and Antiquarian Society, 1879	I. of Man N. H. A. Soc.	P. M. C. Kermode, Hillside, Ramsey, Isle of Man	140	2s. 6d.	Gentlemen, 6s.; Ladies, 3s.	Yn Lioar Manninagh, quarterly.
Manchester Geographical Society, 1885	Manch. Geog. Soc. ..	Eli Sowerbutts, F.R.G.S., 16, St. Mary's Parsonage, Manchester	830	None	Members, £1 1s.; Associates, 10s. 6d.	Journal, quarterly
Manchester Geological Society, 1838..	Manch. Geol. Soc. ..	James Tonge, 36, George Street, Manchester	230	None	£1.	Transactions, eight or nine parts per annum.
Manchester Statistical Society, 1833 ..	Manch. Stat. Soc. ..	63, Brown Street, Manchester. Francis E. M. Beardsall and T. Gregory	220	10s. 6d.	10s. 6d.	Transactions, annually.
Marlborough College Natural History Society, 1864	Marlb. Coll. N. H. Soc.	Marlborough College. E. Meyrick ..	300	1s. 6d.	3s. and 5s.	Report, annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1895–96.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Midland Union of Natural History and Scientific Societies, 1877	Mid. Union	T. V. Hodgson, 15, Lordswood Road, Harborne, Birmingham	12 Societies, 1,200 Membs.	—	3d. per Member	Report, annually.
Norfolk and Norwich Naturalists' Society, 1869	Norf. Norw. Nat. Soc.	W. A. Nicholson, 3, Oxford Street, Norwich	275	None	5s.	Transactions, annually.
North of England Institute of Mining and Mechanical Engineers, 1852	N. Eng. Inst.	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne	1,000	None	21s. and 42s.	"Transactions of The Federated Institution of Mining Engineers," about every two months.
North Staffordshire Naturalists' Field Club and Archæological Society, 1865	N. Staff. N. F. C. A. Soc.	Rev. T. W. Daltry, M.A., Madeley Vicarage, Newcastle, Staffs.	424	5s.	5s.	Report and Transactions, annually.
Northamptonshire Natural History Society and Field Club, 1876	N'ton N. H. Soc. ..	H. N. Dixon, East Park Parade, Northampton	200	None	10s.	Journal, quarterly.
Nottingham Naturalists' Society, 1852	Nott. Nat. Soc.	Henry Wilkins, 35, Alfreton Road, Nottingham	150	2s. 6d.	5s.	Transactions and Report, annually.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst. ..	J. Gardner, 3, County Place, Paisley	370	5s.	7s. 6d. .	Report, annually; Meteorological Observations, occasionally.
Penzance Natural History and Antiquarian Society, 1839	Penz. N. H. A. Soc. ..	Museum, Public Buildings, Penzance. Dr. H. Montgomerie	81	None	10s. 6d.	Report and Transactions, annually.
Perthshire Society of Natural Science, 1867	Perths. Soc. N. Sci. ..	Tay Street, Perth. S. T. Ellison ..	280	2s. 6d.	5s. 6d.	Transactions and Proceedings, annually.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Aahworth, B.Sc., 20, King Street South, Rochdale	254	None	6s.	Transactions, biennially.
Rochester Naturalists' Club, 1878 ..	Rochester N. C.	John Hepworth, Union Street, Rochester	150	None	3s. 6d., 5s., and 10s.	"Rochester Naturalist," quarterly.
Somersetshire Archæological and Natural History Club, 1848	Som'setsh. A.N.H. Soc.	The Castle, Taunton. F. T. Elworthy	556	10s. 6d.	10s. 6d.	Proceedings, annually.
South African Philosophical Society, 1877	S. African Phil. Soc. ..	W. H. Finlay, Royal Observatory, Cape Town	68	None	£2.	Transactions, annually.
Tyneside Geographical Society, 1887 ..	Tyneside Geog. Soc. ..	Geographical Institute, Barras Bridge, Newcastle-upon-Tyne. G. E. T. Smithson	1,000	None	10s.	Journal, half-yearly.
Warwickshire Naturalists' and Archæologists' Field Club, 1854	Warw. N. A. F. C. ..	W. G. Fretton, F.S.A., Hearsall Terrace, Chapel Fields, Coventry	82	2s. 6d.	5s.	Proceedings, annually.
Woolhope Naturalists' Field Club, 1851	Woolhope N. F. C. ..	Woolhope Club Room, Free Library, Hereford. H. Cecil Moore	227	10s.	10s.	Transactions, biennially.
Yorkshire Geological and Polytechnic Society, 1837	Yorks. Geol. Poly. Soc.	Wm. Lower Carter, F.G.S., Hopton, Mirfield	180	None	13s.	Proceedings, annually.
Yorkshire Naturalists' Union, 1861 ..	Yorks. Nat. Union ..	W. Denison Roebuck, F.L.S., Sunny Bank, Leeds	444 and 2,283 Associates	None	Members 10s. 6d.; Associates 1d.	Transactions, annually; "The Naturalist," monthly.
Yorkshire Philosophical Society, 1822	Yorks. Phil. Soc. ..	Museum, York. T. S. Noble, F.G.S.	450	None	£2.	Report, annually.

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Barling, Ivan C.	The Adjustment of Surveying Instruments	Liv'pool E. Soc.	*Trans.*	XV.	35	1894
Bartrum, C. O.	An Open scale Barometer	Fed. Inst. Min. Eng.	,,	VII.	553	,,
Burrow, J. C.	Photography in Mines	Cornw. R. Geol. Soc.	,,	XI.	621	1895
Henderson, Jas.	Magnetic Declination in Mines	N. Eng. Inst.	*Trans. Fed. Inst.*	VIII.	273	1894
Parsons, Dr. H. F.	Earth Temperatures	Croydon M. N. H. C.	*Trans.*	For 1892-93	61	,,
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Section B.—CHEMISTRY.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Bellamy, C. R.	The Science and Progress of Gas Combustion	Liv'pool E. Soc.	*Trans.*	XV.	146	1894
Clowes, Prof. F.	The Proportion of Carbon Dioxide (Choke-damp) in Air which is Extinctive to Flame	Fed. Inst. Min. Eng.	,,	VII.	419	,,
Haldane, J., and W. N. Atkinson	Composition, Occurrence, and Properties of Black-damp	,,	,,	VIII.	349	1895
Kayll, A. C.	Report of the Proceedings of the Flameless Explosives Committee: Part I., Air and Combustible Gases	N. Eng. Inst.	*Pamphlet*			,,
Kendall, J. D.	Miss fires	,,	*Trans. Fed. Inst.*	VII.	605	1894
Oraman, W. J.	Coal-dust Explosions	Manch. Geol. Soc.	*Trans.*	XXIII.	100	1895
Storrie, John	Roman Iron-making at Ely Racecourse	Cardiff Nat. Soc.	,,	XXVI.	139	,,
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* The Titles of Papers on other than Mining and Mechanical Engineering, etc., have not been reprinted.

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Bedford, J. E.	The Mourne Mountains	Leeds Geol. Assoc. ..	*Trans.*	IX.	17	1895
Bell, Dugald	The Glaciation of the West of Scotland..	Edinb. Geol. Soc. ..	,, ...	VII.	49	1894
,, ,, ..	,, ,, ,, ...	Glasgow Phil. Soc. .	*Proc.*	XXV.	118	,,
Bird, Charles	On so-called Changes of Level	Rochester N. C.	*Roch. Naturalist*..	II.	257	,,
Bolton, Herbert	Note on some Fossil Trees at Doulton's Delf, St. Helen's, Lancashire ..	Manch. Geol. Soc. ..	*Trans.*	XXIII.	73	1895
,, ..	On the Metamorphism of Coal	,, ..	,, ...	,,	122	,,
Boulton, W.	The Geology of the Precious Metals	Birm. N. H. Phil. Soc..	*Journal*	I.	79	1894
,, ,, ..	,, ,, Part II.	,, ..	,, ...	,,	90	1895
Cadell, H. M.	The New Geological Map of the Edinburgh District	Edinb. Geol. Soc. ..	*Trans.*	VII.	15	1894
,, ..	Petroleum and Natural Gas..	,, ,, ..	,, ...	,,	51	,,
Callaway, C.	Fossil Shells from Gloppa	Car. and Sev. Vall. F. C.	,, ...	I. No. 2	9	1895
Calvert, A. F.	Western Australia and its Gold-fields	Edinb. Geol. Soc. ..	,, ...	VII.	1	1894
Cantrill, T. C.	On some Drift at Bissell Hill, near Kidderminster	Birm. N. H. Phil. Soc..	*Journal*	I.	141	1895
Carter, Rev. W. L. ..	A Petrological Description of Rock Sections	Leeds Geol. Assoc. ..	*Trans.*	IX.	11	,,
,, ,, ..	A Peep into Nature's Sculpture Gallery	,, ,, ..	,, ...	,,	12	,,
,, ,, ..	A Walking Tour in Cornwall	,, ,, ..	,, ...	,,	20	,,
Cobbold, E. S.	The Surface Appearance of the Dartmoor Granite	Car. and Sev. Vall. F. C.	,, ...	I. No. 2	3	,,
,, ,, ..	Notes on the Geology of Cornwall	,, ,, ..	,, ...	,,	15	,,
Collins, J. H.	Illustrations of Cornish Fossils: Further Notes on *Petralia*	Cornw. R. Geol. Soc. ..	,, ...	XI.	644	,,
Currie, J.	The Copper Mines of Namaqualand	Edinb. Geol. Soc. ..	,, ...	VII.	30	1894
Cuttriss, S. W.	Norway	Leeds Geol. Assoc. ..	,, ...	IX.	47	1895
Davis, Prof. W. M. ..	Note on Croll's Glacial Theory	Edinb. Geol. Soc. ..	,, ...	VII.	77	1894
Dawkins, Prof. W. Boyd	The Probable Range of the Coal-measures in Southern England	Fed. Inst. Min. Eng. ..	,, ...	,,	533	,,
,, ,,	The Geology of the Isle of Man	Manch. Geol. Soc. ..	,, ...	XXIII.	147	1895
Dickson, E...	The Ribble Estuary, with Notes on the Formation of Sand and the Disposal of Dissolved Matter in River Water	Liv'pool Geol. Soc. .	*Proc.*	VII.	135	1894
Dickson, E., & P. Holland	Notes on Shell Breccia dredged off the Coast of the Isle of Man; and on the Source of the Carbonate of Lime of the Shells of Marine Organisms	,, ,, ..	,, ...	,,	164	,,
Dow, R.	Outcrop of Diabase at Rosie Priory	Perths. Soc. N. Sci. ..	*Trans. and Proc.*	II.	1	1895
Dowker, G.	Report on Lenham Excursion	E. Kent N. H. Soc. ..	*S. E. Naturalist* ..	IV.	114	,,
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Fitzpatrick, J. J... ..	The Permian Conglomerate of the Vale of Eden	Liv'pool Geol. Soc. ..	*Proc.*	VII.	212	1894
Foniakoff, A.	The Gold Deposits of Siberia	Fed. Inst. Min. Eng. ..	*Trans.*	,,	445	,,
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Groom, T. T.	Mountains, Valleys, Lakes, and Fjords..	Leeds Geol. Assoc. ..	,, ...	IX.	34	1895

Name of Author.	Title of Paper.	Abbreviated Title of Society.	Title of Publication.	Volume or Part.	Page.	Published.
Gunn, Rev. Geo.	Rocks of Newton Don	Berwicksh. Nat. Club	*History*	1892-93.	313	1894
Herdman, Prof. W. A.	Notes on the Submarine Deposits of the Irish Sea	Liv'pool Geol. Soc.	*Proc.*	VII.	171	"
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Kendall, Percy F.	The Ancient and Modern Glaciers of North America	Leeds Geol. Assoc.	*Trans.*	IX.	37	1895
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Sanford, W. A.	On the Bones of an Animal resembling the Megalosaur found in the Rhætic Formation at Wedmore	Som'setsh. A. N. H. Soc.	*Proc.*	XL. Pt. II.	227	1894
Seward, A. C.	A New British Carboniferous Fossil	Yorks. Nat. Union ..	*The Naturalist* ..	For 1894	233	,,
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Somervail, A.	On the Probable Age of the Lizard Rocks	Cornw. R. Geol. Soc. ..	*Trans.*	XI.	662	,,
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Castle, E. J.	Rating of Mines	Fed. Inst. Min. Eng.	*Trans.*	VII.	428	1894
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Ferguson, Prof. J.	On the Work of the Philosophical and other Scientific Societies	Glasgow Phil. Soc.	*Proc.*	XXV.	1	"
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Inglis, John	The Apprentice Question	Glasgow Phil. Soc.	*Proc.*	XXV.	170	1894
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Miscampbel, A.	The Salt Industry of Carrickfergus	"	"	"	546	"
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Boult, W. S.	Some Methods of Regulating Pressure in Electric Light Circuits	Liv'pool E. Soc.	*Trans.*	XV.	165	"
Brunck, R.	The Brunck Coke-oven and System for the Recovery of Bye-products	N. Eng. Inst.	*Trans. Fed. Inst.*	IX.	47	1895
Burton, G. L.	A Tour in South Africa, with Reference to Engineering Work Past and Present	Liv'pool E. Soc.	*Trans.*	XV.	66	1894
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Holmes, A. B.	The Public Supply of Electrical Energy: its Cost and Price	Liv'pool E. Soc.	*Trans.*	XV.	86	"
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Jeans, J. S.	The Comparative Conditions and Costs of Transport by Railway and Canal	Fed. Inst. Min. Eng.	*Trans.*	VIII.	432	1895
MacWhirter, Wm.	Modern Electrical Inventions	Belfast N. H. Phil. Soc.	*Report and Proc.*	1893-94.	52	"
Main, J. M.	The Working of Hæmatite in the Whitehaven District	N. Eng. Inst.	*Trans. Fed. Inst.*	VIII.	31	1894
Martin, E. D.	The Severn Navigation, with Particular Reference to Recent Improvements	Fed. Inst. Min. Eng.	*Trans.*	"	499	1895
Mathews, D. H. F.	On Damping Dust in Mines	Manch. Geol. Soc.	"	XXIII.	90	"
Mellon, H.	The Mining of the Softer Ores of Furness	N. Eng. Inst.	*Trans. Fed. Inst.*	VIII.	44	1894

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Moore, R. W.	Historical Sketch of the Whitehaven Collieries	N. Eng. Inst.	*Trans. Fed. Inst.*	VII.	613	1894
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Saint, William	Improvements in Water-spraying Apparatus for Damping Dust in Mines	Manch. Geol. Soc.	,,	XXIII.	225	1895
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Sayers, W. B.	Dynamo-Electric Machinery	Glasgow Phil. Soc.	*Proc.*	XXV.	196	,,
Scoular, George	Description of the St. Helen's Colliery, Workington	N. Eng. Inst.	*Trans. Fed. Inst.*	VII.	643	,,
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Spargo, Edmund	Lithographic Stone and its Uses	Fed. Inst. Min. Eng.	*Trans.*	,,	568	1895
Spencer, Wm.	Presidential Address	Chesterf. Mid. Count. Inst.	*Trans. Fed. Inst.*	VII.	661	1894
Stetefeldt, C. A.	The Stetefeldt Furnace	Fed. Inst. Min. Eng.	*Trans.*	VIII.	93	,,
Tate, Simon	Saving of Life from After-damp, Smoke, or Fumes in Mines	N. Eng. Inst.	*Trans. Fed. Inst.*	,,	189	,,
Thwaite, B. H.	Engineering Heliography, or the Sun-print Copying of Engineering Drawings	,, ,,	,, ,,	IX.	69	1895
Watts, William	On Waterworks Construction and the Use of Concrete and Earthwork in forming Embankments	Manch. Geol. Soc.	*Trans.*	XXIII.	42	1894
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* * *	* * * * * * * * * *	* * *	* * *	* *	*	* *

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Darwin, W. E.	Bronze Implements found at Bitterne	Hants. F. C.	*Proc.*	III.	53	1895
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Section K.—BOTANY.

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INDEX TO VOL. X.

EXPLANATIONS.

The — at the beginning of a line denotes the repetition of a word; and in the case of Names, it includes both the Christian Name and the Surname.

Discussions are printed in *italics*.

The following contractions are used:—

C.—Chesterfield and Midland Counties Institution of Engineers.

M.—Midland Institute of Mining, Civil, and Mechanical Engineers.

S.—Mining Institute of Scotland.

N.E.—North of England Institute of Mining and Mechanical Engineers.

N.S.—North Staffordshire Institute of Mining and Mechanical Engineers.

S.S.—South Staffordshire and East Worcestershire Institute of Mining Engineers.

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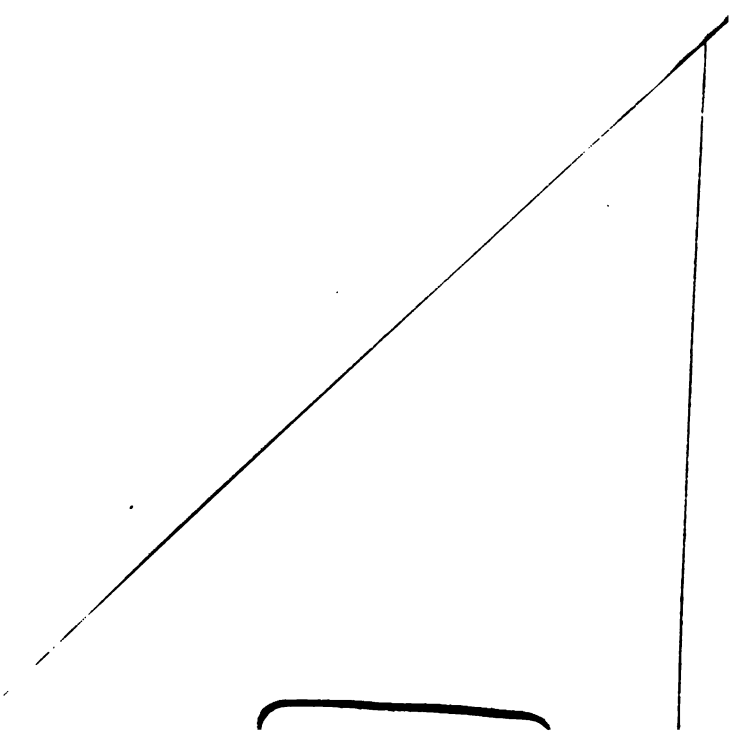
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